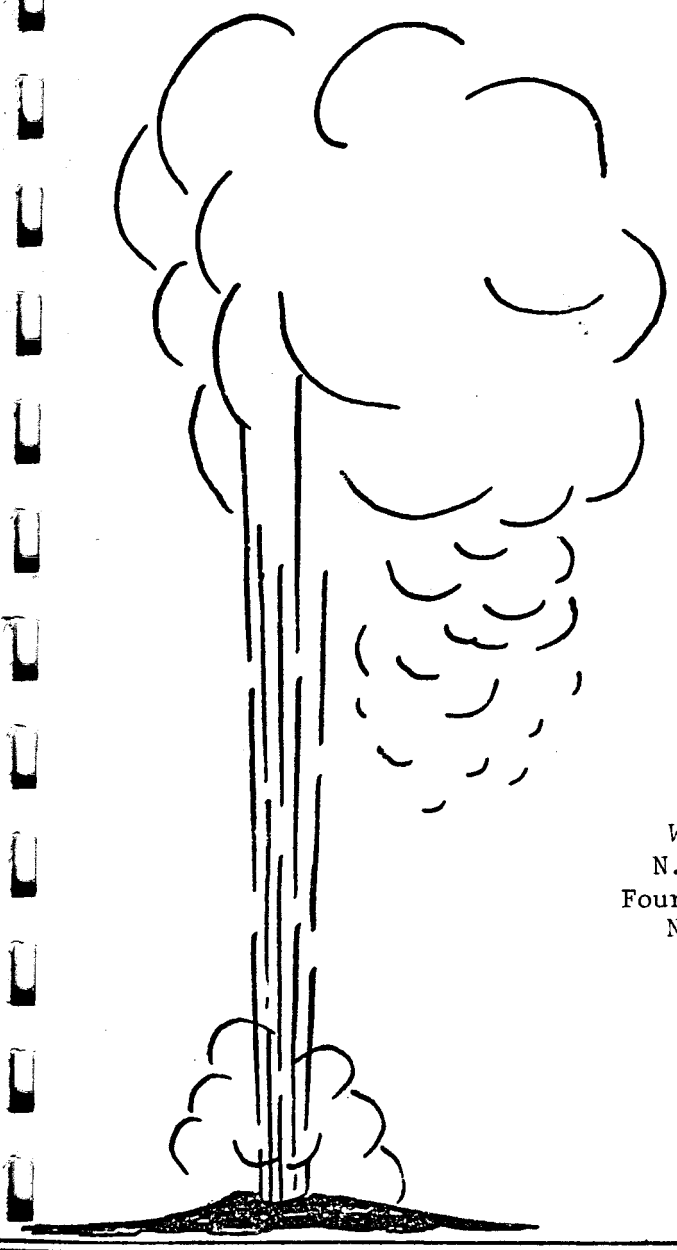
ALO-3992

# NEW MEXICO SOUTHWEST REGIONAL GEOTHERMAL DEVELOPMENT OPERATIONS RESEARCH PROJECT

Appendix 9 of

REGIONAL OPERATIONS RESEARCH PROGRAM
FOR DEVELOPMENT OF GEOTHERMAL ENERGY
IN THE SOUTHWEST UNITED STATES



Final Technical Report
June 1977 to August 1978

New Mexico Energy and
Minerals Department
Thomas A. Ortiz
Dennis Fedor

January 1979

Work Performed under DOE Contract No. EG-77-S043992
N.M.Energy and Minerals Department Project No. 76-262
Four Corners Regional Commission Contract No. 672-066-075
New Mexico State University Sub-Contract No. 5104-X7

New Mexico Energy Institute at
New Mexico State University
Las Cruces, New Mexico 88003

**U. S. DEPARTMENT OF ENERGY**

**Geothermal Energy**

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## EXPLANATION AND ACKNOWLEDGMENTS

This project was funded by the U.S. Department of Energy, the Four Corners Regional Commission and the New Mexico Energy Resources Board (now the New Mexico Energy and Minerals Department). The Energy and Minerals Department, is a subcontractor to the contractor, the New Mexico Energy Institute. Mr. Thomas Ortiz, Director, Energy and Resources Development Division, was the Team Leader for the project.



Numerous individuals provided information and assistance for this study. Their help is greatly appreciated. While it is not possible to list everyone here, special mention should be made of the Members of the State Advisory Team:

Dan Nutter, Chief Engineer, N.M. Oil Conservation Division, EMD

Jack Kennedy, Division Director, N.M. State Land Office

George Scudella, Energy Coordinator, N.M. Environmental Improvement Division, HED

Anthony Garcia, N.M. Public Service Commission

Emery Arnold, Director, Mining and Minerals Division, EMD

Dr. Frank Kottlowski, Director, N.M. Bureau of Mines & Minerals

Art Martinez, Public Service Company of New Mexico

Mort Smith, Assistant Division Leader, Geothermal, Los Alamos Scientific Laboratory

H.M. Stoller, Geothermal Energy Technology Dept., Sandia Laboratories

Dr. George Jiracek, Geophysicist, University of New Mexico

Al Utton, Professor of Law, University of New Mexico

J. K. Couzens, N.M. State Engineer's Office

Don Isbell, Vice President, Energy Resources and Planning, El Paso Electric

Keith M. Dotson, Four Corners Regional Commission

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Dr. Richard T. Meyer, Western Energy Planners, Consultant to the South west Regional Geothermal O/R Project

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Marshall Reiter and William Stone, New Mexico Bureau of Mines

Dr. Allen Sanford, New Mexico Institute of Mining & Technology

Dr. R. San Martin, Director, New Mexico Energy Institute

Dr. Chandler Swanberg, New Mexico State University

Carl Ulvog, New Mexico Oil Conservation Division, EMD

A. F. Veneruso, Sandia Laboratories

# INTRODUCTION

This final report describes the findings and conclusions of the New Mexico Team during the first project year of the Southwest Regional Geothermal Development Operations Research Project. The purpose of this project is to help realize a goal of the U.S. Department of Energy, Division of Geothermal Energy (DOE/DGE), "to accelerate the actual commercial utilization of geothermal energy." This was done by:

1) Identifying the potential for development of geothermal energy in the five-state regions of Arizona, Colorado, New Mexico, Nevada and Utah.

2) Identifying the actions needed to accomplish that development.

Funding was provided to the prime contractor, the New Mexico Energy Institute, by the DOE/DGE, assisted by the Four Corners Regional Commission and the New Mexico Energy and Minerals Department (formerly Energy Resources Board) Each state arranged for a subcontractor. In New Mexico the subcontractor is the New Mexico Energy and Minerals Department, with its staff members comprising the State Team. The team is led by Thomas A. Ortiz, Director of the Energy Resources Development Division in the New Mexico Energy and Minerals Department. Working with Mr. Ortiz are the energy consultants of the division: Dennis Fedor and Gary Carlson and also the staff members of the Mining & Minerals Division/EMD, Kay Hatton and Wes Horner. The latter three have, in part, assisted in different phases of the project.

The state team has contacted federal, state and local government entities involved in geothermal energy development including legislative bodies, universities, utilities, both national laboratories of Sandia and LASL, and members of the general public. Geothermal developers and academic researchers in the state were contacted in order to determine the extent of speculative projections and development plans for any of the potential geothermal resource areas.

Numerous field trips were made to ascertain the degree of geothermal potential and activity. These included BLM inspection trips to Socorro and Radium Springs and investigations of the San Ysidro, Jemez Springs and Soda Dam thermal areas.

This project has stimulated much interest and planning in many sectors of the state. Some state agencies including the Energy and Minerals Department have initiated effort to create legal, institutional and economic inducements in state energy policies and plans in order to stimulate geothermal development.

The state team was responsible for drawing up the state policies for geothermal energy in the State Energy Plan. A number of recommendations have been made in the State Energy Plan which include income tax credit for geothermal systems (outfitting and retrofitting) and a public awareness outreach program. Other accomplishments were: state position paper for the National Governor's Energy Production Conference held in February; reviewed and responded to the Bureau of Land Management's environmental assessment report on geothermal leasing in the Silver City area; reviewed and responded to BLM's inquiry for

an EAR in the Ojo Caliente area. The state team and EMD has given support to PNM/Union Oil proposal for DOE funding through the geothermal demonstration plant program. It also is supporting the geothermal depletion allowance in the National Energy Plan.

The state team has participated in promoting interest in and reviewing the state research and development geothermal programs. The number of these programs have increased noticeably during the past six months.

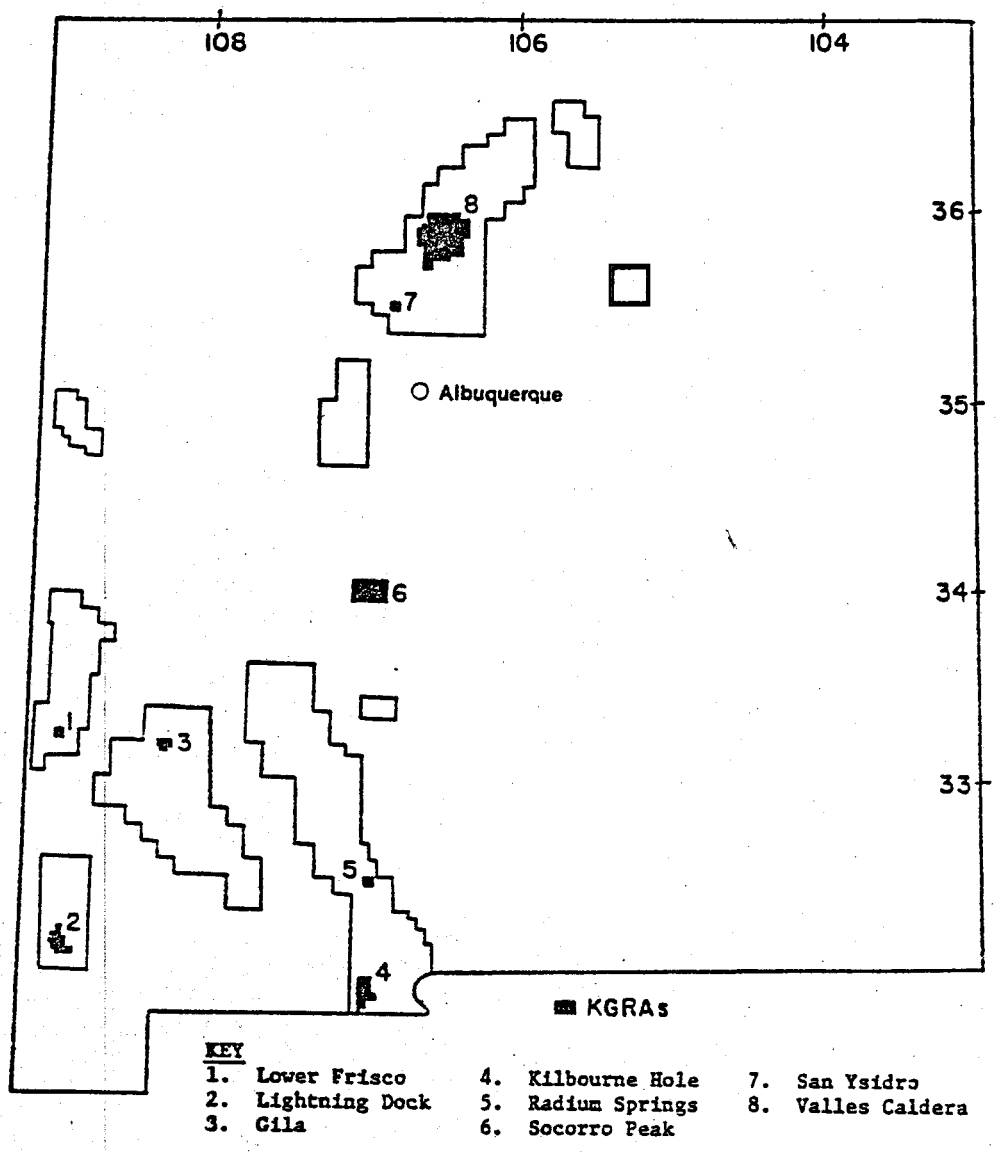



Figure 1. New Mexico Geothermal Resource Areas

## GEOTHERMAL POTENTIAL IN NEW MEXICO

The State of New Mexico exhibits virtually all known kinds of potential geothermal resources and will soon have the nation's first commercial-scale plant to use underground reserves of hot water which is located in the Jemez Mountains.

The State has many visible manifestations such as geologically recently active volcanoes, lava fields and it also has over a hundred hot springs. In general, nearly all of these are confined to the two major geothermal areas in New Mexico. These are the Rio Grande Rift, and the southwestern portion of the state.

The Rio Grande Rift is a linear structural fault zone which literally bisects the state in a north-south direction. This rift extends through many areas of volcanism and mountain building and generally parallels or occupies the geographic position of the state's major river.

Because it is a series of faulted troughs or basins, many small volcanoes and fissure flows mark the boundaries at several localities. Numerous warm and hot springs, having temperatures greater than $65^{o}F$, are found along the faults which border the trough. Apparently, ground water circulates into zones of hot rock and then finds a convenient conduit to the surface along the faults. According to the heat flow data complied by Reiter and others (1975), a high heat flow ridge coincides with the western boundary of this rift. The heat flow here is greater than 2.5 HFU (normal average is 1.5 HFU) as shown in Figure 2. The Rio Grande Basin from Colorado to Texas is filled with relatively unconsolidated sands, gravels and clays eroded from nearby mountain uplifts that are thousands of feet thick in many regions. These sediments are saturated with ground water that, at depth, can be expected to exhibit features of geothermal high temperature systems. With most of the state's population occupying this zone, the implications of commercial development are obvious.

The source of heat from most of the commercial geothermal power station in the world can be traced to fairly recent igneous activity associated with fault zones.

In New Mexico, warm and hot springs are for the most part in areas of obvious volcanism. Figure 2 shows where igneous rocks of Quaternary and Pliocene ages crop out in the state. Many volcanic cones dot the state's landscape. The preliminary state geologic maps (Dane and Bachman, 1957, 1958, 1961; Bachman and Dane, 1962) show the location of these cones in considerable more detail than is possible here. Because New Mexico has so many fairly recent volcanoes, the prospects of finding and developing hydrothermal water and steam, are good, and could become the major energy used to generate power in the state.

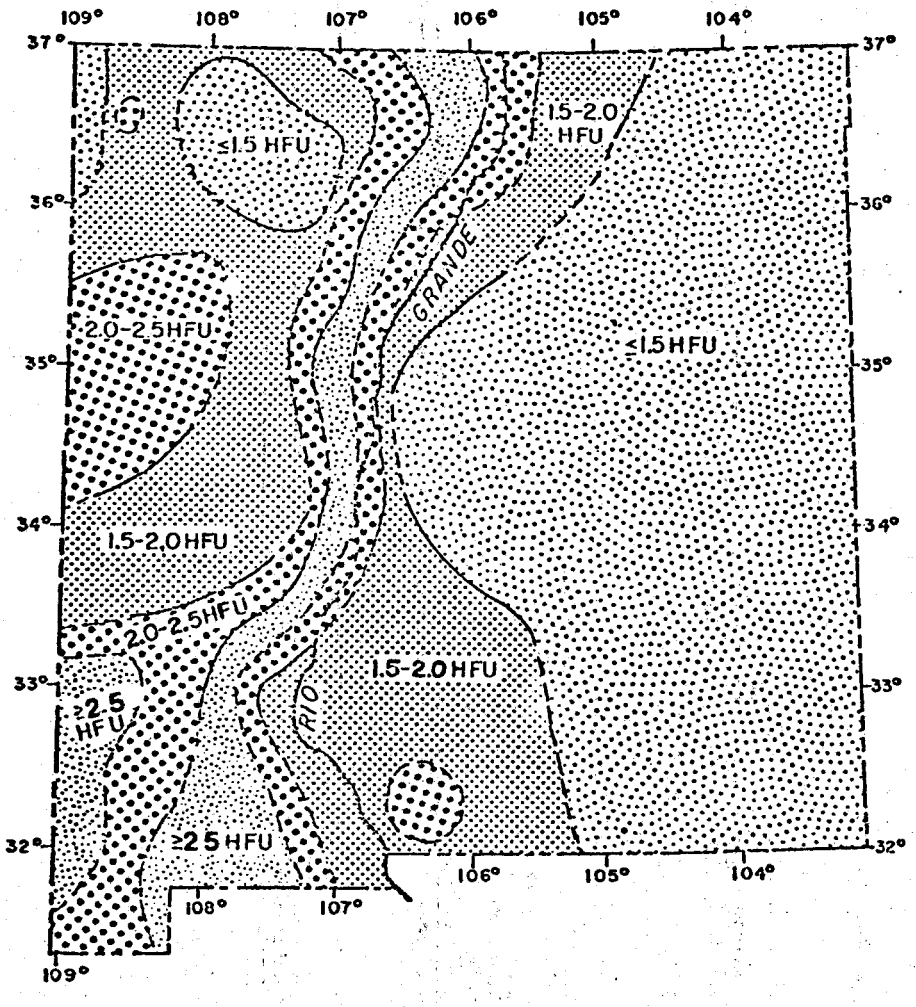



FIGURE 2 - - Terrestrial heat-flow contour map of New Mexico. Contour interval = 0.5 hfu (modified from Reiter and others, 1975).

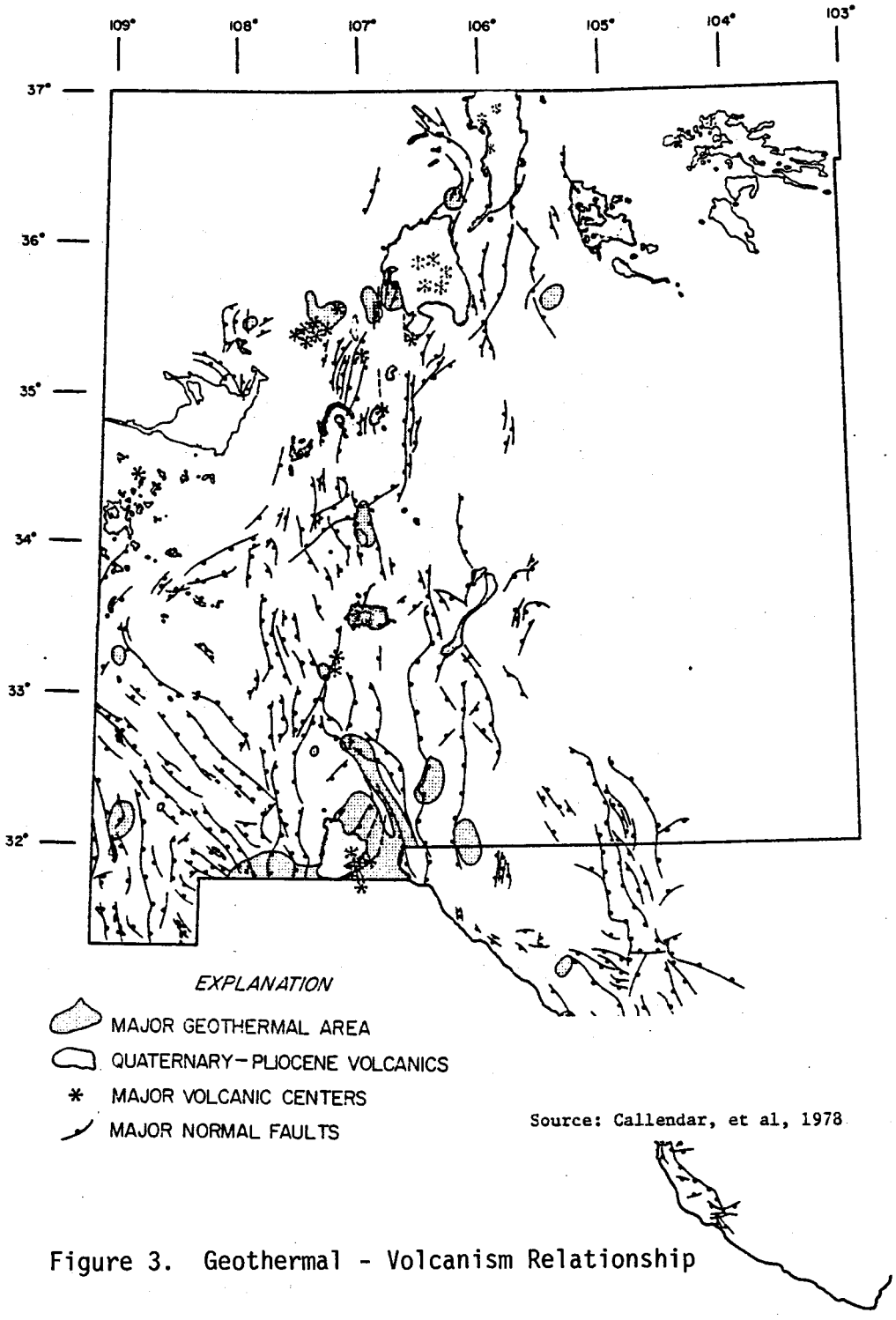



Figure 3. Geothermal - Volcanism Relationship

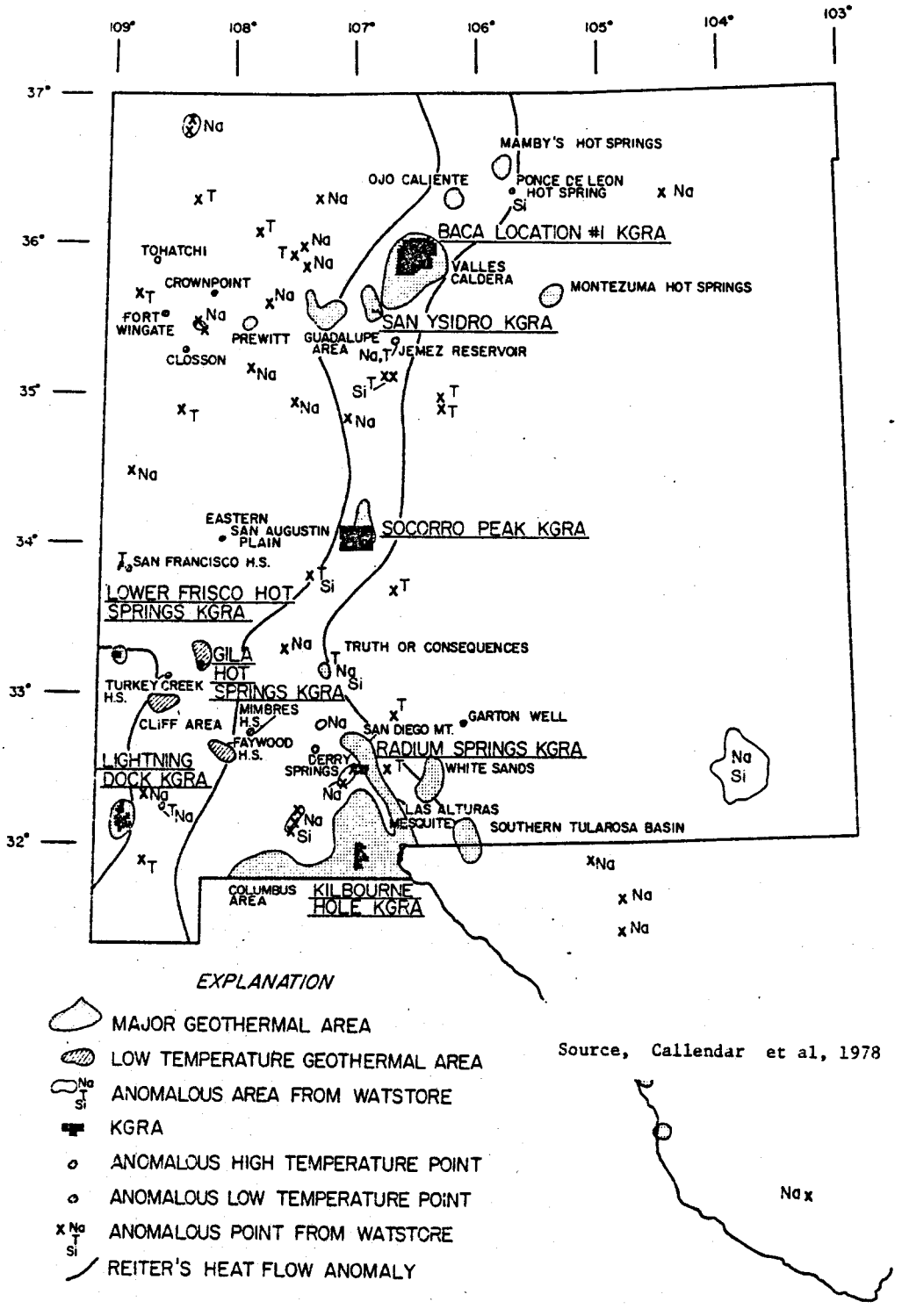



Figure 4. Geothermal Base Data Map

## STATUS OF GEOTHERMAL DEVELOPMENT

### Current Situation

Until recent years, New Mexico's heat resource was used only in resort spas, where the discharging waters of hot springs or the deposits they build attract tourists. Some small use is also made of hot springs as water supplies for irrigation, livestock or communities, but these uses do not take advantage of thermal properties of the water. In some instances, the anomalous temperature of the water detracts from its use.

Although a great amount of interest exists in New Mexico's geothermal resource, there are relatively few situations where it has been practically applied. There are only a few buildings in New Mexico presently using geothermal energy for space heating or cooling. No where in the state is geothermal energy currently used to generate electricity on a commercial basis although Union Oil will put its first plant on line in 1982. A listing of the current uses of geothermal energy in the state is in Table 1.

Due to the strong interest expressed by private industry, the federal government, the State of New Mexico and municipal governments, a multitude of projects are under way aimed at using the enormous capabilities of this energy resource.

One of the most promising state geothermal areas lies in the Valles Caldera, an ancient volcano in the Jemez Mountains West of Los Alamos (Baca Location No. 1 KGRA). Here, Union Oil Company of California drilled wells ranging in depth from 6,000 to 9,000 ft. and cost from $500,000 to $1,000,000 per well. Of the 17 tests drilled to date, 6 are reported to have produced hot water and/or wet steam with temperatures of about 495°F. Public Service Company of New Mexico, the state's largest electric utility, has joined with Union Oil Company in submitting a proposal to the U.S. Department of Energy for a 50 MW geothermal generation facility. Funding has recently been approved and the plant should be producing by 1982.

Other drilling activity in the state includes operations by Sunoco Development Company, Amax Exploration, Chevron Oil, Sandia Laboratories and the State of New Mexico. Each of these entities has already started drilling or is about to start drilling operations utilizing hydrothermal systems. In addition, a number of other entities hold geothermal leases which are expected to eventually lead to drilling programs.

In addition to the hydrothermal system projects, a major experiment also is underway utilizing hot, dry rock. Los Alamos Scientific Laboratory is coordinating this project, the only one of its kind in the United States, at a site near Fenton Lake. Here, cool water is pumped deep into the ground, heated by fractured rocks and recovered as steam. The project has resulted in numerous technical achievements including the development of the nation's only hot, dry rock generating facility in the nation. In September 1977, a 4 megawatt thermal energy extraction loop was operated for approximately 100 hours. This experiment has attracted international attention. LASL and the Italian National Electrical Agency have agreed to cooperate in geothermal research on reservoir stimulation. West Germany, Austria, and Japan may join in a partnership with LASL in the HDR project.

Currently, LASL is enlarging the facilities at Fenton Lake that will include larger piping and pumping capacities. New tests are expected to start before September and energy extraction should achieve at least 10 megawatts thermal. New drilling that go 4,000 feet deeper into hotter rock will begin in the early part of 1979.

TABLE 1

CURRENT USE OF
GEOTHERMAL ENERGY IN THE STATE

| | |
|---|---|
| SPACE HEATING: | Animas Valley<br>Truth or Consequences (Yucca Lodge)<br>Gila Hot springs<br>Albuquerque (Sandia Savings Building) |
| GREENHOUSES: | Jemez Springs<br>Silver City<br>Animas Valley |
| RESORT SPAS AND BATHOUSES: | Faywood Springs<br>Radium Springs<br>Jemez Hot Springs<br>Gila Hot Springs<br>Ojo Caliente<br>San Antonio Warm Spring<br>Mamby's Hot Spring<br>Upper San Francisco Hot Spring<br>Mimbres Hot Springs |
| SWIMMING POOLS: | Truth or Consequences:<br>Carrie Tingley Hospital<br>Yucca Lodge<br><br>Faywood Hot Springs:<br>Southwestern Services to Handicapped Children and Adults<br><br>Radium Hot Springs Health Resort<br>Ojo Caliente Mineral Springs Co.<br>Jemez Hot Spring (Village operated)<br>Ponce de Leon Hot Springs (private)<br>Montezuma Hot Springs (private) |
| WATER SUPPLY: | San Antonio Spring (home)<br>Socorro (Community)<br>Gila Hot Springs (Ranch and Lodges)<br>Animas Valley (Ranches)<br>Las Alturas (Subdivision)<br>Kennecott Warm Springs (Kennecott Copper Co.)<br>Apache Tejo Hot Springs (Kennecott Copper Co.) |

TABLE 2

STEPS FOR GEOTHERMAL RESOURCE DEVELOPMENT

| MINIMUM TIME | ACTIVITY |
|---|---|
| 2 mo. | PRELIMINARY EVALUATION OF AREAS |
| | OBTAIN LEASES |
| 2 mo. | BLM |
| 3 mo. | USFS |
| 7-8 mo. | State |
| ? | Fee |
| | PERMITS FOR GRADIENT HOLES |
| 2 mo. | State |
| 3 mo. | USGS |
| 1 mo. | USFS |
| 2 mo. | CONTRACT FOR DRILLING |
| ½ | DRILL GRADIENT HOLES & EVALUATE |
| 3 mo. | REASIBILITY AND ENGINEERING STUDIES |
| | OBTAIN FINANCING FOR EXPLORATORY WELLS |
| 1 mo. | Loan |
| 6 mo. | Bond Issue |
| 6 mo. | Government |
| | PERMITS FOR EXPLORATORY WELLS |
| 2 mo. | State - OCD, Engineer |
| 3 mo. | USGS |
| 1 mo. | USFS |
| 2 mo. | City or County (if necessary) |
| 2 mo. | HIRE DRILLING CONTRACTOR |
| 1 mo. | DRILL EXPLORATORY WELL |
| 1 mo. | EVALUATE POTENTIAL OF RESOURCE |
| 1 mo. | OBTAIN WATER RIGHTS IF NECESSARY |
| 1 mo. | SECURE MARKET OR ESTABLISH HEATING/COOLING DISTRICT |
| | OBTAIN FINANCING FOR DEVELOPMENT |
| 1 mo. | Loan |
| 6 mo. | Bond Issue |
| 6 mo. | Government |
| 2 mo. | PERMITS FOR DEVELOPMENT |
| 3 mo. | R.O.W. FOR PIPELINES |
| 2 mo. | CONTRACT FOR CONSTRUCTION OF FACILITIES |
| 6 mo. | INSTALL SYSTEM |
| 1 mo. | OBTAIN FINANCING FOR PRODUCTION WELLS |
| 1 mo. | Loan |
| 6 mo. | Bond Issue |
| 6 mo. | Government |
| | PERMITS FOR PRODUCTION, DISPOSAL, ETC. |
| 2 mo. | State |
| 15 mo. | USGS |
| 1-18 mo. | USFS |
| 6 mo. | County or City |
| 2 mo. | HIRE DRILLING CONTRACTOR |
| 1 mo. | DRILL ONE WELL |

Source: Coe, B, 1978

## LEASING

Leases for geothermal development are currently being granted on Federal, State, and private lands within New Mexico. At present, the U.S. Geological Survey (USGS) has designated eight "Known Geothermal Resource Areas" (KGRA's). KGRA's serve to define areas of active interest.

Six of the eight New Mexico KGRA's are classified by the USGS as being in the intermediate and high temperature hot water convection system range. The eight KGRA's and associated temperatures are:

1) Baca Location No. 1, Sandoval County, 240°C (464°F).

2) Radium Hots Springs, Dona Ana County, 130°C (266°F).

3) Lower Frisco Hot Springs, Catron County 150°C (320°F).

4) Gila Hot Springs, Grant County, 125°C (257°F).

5) Lightning Dock, Hidalgo County, 170°C (388°F).

6) San Ysidro Hot Springs, Sandoval County, 80°C.

7) Kilbourne Hole, Dona Ana County, 155°C (311°F).

8) Socorro Peak, Socorro County, 72°C (161°F).

Baca No. 1 and Socorro Peak were designated KGRA's by USGS because of geologic evidence. The others were designated KGRA's because of competitive interest as defined by the simultaneous filing of the lease applications where the lands applied for in two separate applications overlapped each other by half or more. Each KGRA (leased by competitive bid) along with its buffer zone of marginal interest (non-competitive), many contain Federal, State, or private lands.

The distinction between KGRA leases and non-KGRA leases is that the former requires bonus bidding between competing entities for the lease. Geothermal leases outside KGRA's are issued to the first applicant to file for them and pay the first year's rental of $2 per acre.

Presently, all but two of these KGRA's have been opened for Federal leasing of the geothermal resources. Lower Frisco Hot Springs and Gila Hot Springs KGRA's are closed to Federal leasing right now. The U.S. Forest Service will soon complete Environmental Statements on geothermal leasing in these areas and will make a decision to lease or not to lease them.

To date, 40 competitive leases governing 28,698 ha. (70,911 ac.) and 45 non-competitive leases on 35,812 ha. (88,490 ac.) have been let on public lands. In addition, 186 non-competitive lease applications are still pending in New Mexico on approximately 150,185 ha. (371,098 ac.) of Federal lands and on State and private lands with minerals reserved to the Federal government.

The State of New Mexico also had issued geothermal leases on 63,374 acres. The State conducted lease sales on August, 1974, March 1975, July 1975 and October 1975; however, bids were received only for lands within or near indicated thermal anomalies and these lands were subsequently leased. The State Land Office has not issued any state leases since 1975. Neither the State nor the Federal Government keep records concerning the leasing of geothermal resources on private lands. Although some private holdings have been leased, many land owners are refraining from leasing to see what develops on leased lands adjacent to their property.

Indicative of increasing interest in New Mexico's geothermal potential are the prices received as bonuses at the BLM sale in May 1977. Aminoil, USA bid $133.76 per acre for 2,810 acres offered in the Baca Location No. 1 KGRA, an amount greater than many very competitive oil and gas leases receive.

TABLE 3

CONTROLLING AGENCY

NEW MEXICO GEOTHERMAL SURFACE AREA

| Controlling Agency | Explored Sites[1] (Acres) | Unexplored Sites[2] (Acres) | Totals |
|---|---|---|---|
| Federal | | | |
| Public (BLM) | 203,162 | 61,600 | 264,762 |
| National Forest | 59,821 | 9,000 | 68,821 |
| Military | | 7,000 | 7,000 |
| National Park/Mounment | | 1,000 | 1,000 |
| Indian | 30,000 | 4,000 | 34,000 |
| State | 87,709 | 3,000 | 90.709 |
| Private | 183,208 | 20,500 | 203,708 |
| TOTAL | 563,900 | 106,100 | 670,000 |
| Number of Sites | 18 | 41 | 59 |

[1]Explored sites include 8 KGRA's plus current leases outside the 8 KGRA; plus 10 other sites.

[2]Unexplored sites are probable surface area subject to exploitation (in most cases default value of 1000 acres is assumed) plus pending leases. As exploration continues, it can be expected that the site size of unexplored sites will expand.

TABLE 4

LEASING STATUS OF STATE LANDS IN NEW MEXICO

| Acres Available | Acres Accepted | Remaining for Lease | Number of Leases Issued |
|---|---|---|---|
| 13,000,000* | 63,374 | 12,936,626 | 147 |

*All state land is available even though it might not be suitable for geothermal development.

LEASING STATUS OF FEDERAL LANDS IN NEW MEXICO

| Federal Agency | Acres Theoretically Available | Acres Offered | Acres Bid on | Acres Accepted | Remaining For Lease |
|---|---|---|---|---|---|
| Bureau of Land Management | 190,320 | 101,693 | 62,482 | 62,484 | 127,838 |
| Forest Service | 1,224,004 | 29,375 | 18,050 | 18,050 | 1,205,954 |

FOREST SERVICE NON-COMPETITIVE GEOTHERMAL LEASING AS OF 12/77 IN NEW MEXICO

| | |
|---|---|
| Number of Applications | 42 |
| Number Issued | 0 |
| Number Pending | 27 |

BUREAU OF LAND MANAGEMENT NON-COMPETITIVE GEOTHERMAL LEASING AS OF 12/77 IN NEW MEXICO

| | |
|---|---|
| Number of Applications | 574 |
| Number Issued | 85 |
| Number Pending | 146 |

AGE OF FEDERAL LAND NON-COMPETITIVE LEASE APPLICATIONS STILL PENDING AS OF 4/78

| Agency | 5 Months or less | 6-11 Months | 12-17 Months | 18-23 Months | 24-35 Months | 36 Months or More | Totals |
|---|---|---|---|---|---|---|---|
| Bureau of Land Management | 23 | 11 | 24 | 0 | 8 | 144 | 210 |
| Forest Service | 6 | 5 | 0 | 0 | 3 | 23 | 42 |

TABLE 5

FEDERAL ACTIVE NON-COMPETITIVE GEOTHERMAL LEASES
IN NEW MEXICO AS OF MARCH 30, 1978

| LESSEE (OR ASSIGNEE) | ACRES | TOWNSHIP & RANGE | DATE ISSUED |
|---|---|---|---|
| Jack F. Grimm | 2,560.00 | T. 26 S., R. 1 E. | 6-11-75 |
| (Assignee) | 2,508.36 | T. 25&26 S., R. 1 E. | 6-11-75 |
| | 1,195.85 | T. 25 S., R. 1 E. | 6-11-75 |
| Jack F. Grimm | 1,176.80 | T. 25 S., R. 1 E. | 6-11-75 |
| | 2,127.10 | T. 25 S., R. 1 E. & T. 26 S., R. 1 E. | 6-11-75 |
| Oxy Petroleum Corp. | 1,200.00 | T. 15 N., R. 1 E. | 1-07-77 |
| Lamar Hunt | 2,560.00 | T. 28 S., R. 2 W. | 5-29-75 |
| (Assignee) | 2,560.00 | T. 28 S., R. 2 W. | 5-29-75 |
| | 2,557.96 | T. 28 S., R. 2 W. | 5-29-75 |
| | 1,918.20 | T. 28 S., R. 2 W. | 5-29-75 |
| | 2,560.00 | T. 28 S., R. 2 W. | 5-29-75 |
| Caroline Lewis Hunt | 1,230.92 | T. 27 S., R. 1&2 W. | 5-30-75 |
| (Assignee) | 2,160.00 | T. 27 S., R. 2 W. | 5-30-75 |
| Norma Knobel Hunt | 2,422.02 | T. 29 S., R. 1 W. | 5-29-75 |
| (Assignee) | 2,302.36 | T. 29 S., R. 2 W. | 5-29-75 |
| | 1,662.66 | T. 29 S., R. 1&2 W. | 4-28-76 |
| | 1,919.90 | T. 29 S., R. 1&2 W. | 5-29-75 |
| Aminoil USA, Inc. | 965.97 | T. 23&24 S., R. 19 W. | 12-28-76 |
| Aminoil USA, Inc. | 1,280.00 | T. 24 S., R. 19 @. | 12-28-76 |
| | 518.00 | T. 23&24 S., R. 19 W. | 11-30-76 |
| | 1,931.24 | T. 24 S., R. 19 W. | 11-30-76 |
| U.S. Geothermal Corp. | 1,285.32 | T. 26 S., R. 19 W. | 1-07-77 |
| U.S. Geothermal Corp. | 1,029.253 | T. 25 S., R. 12 W. | 1-07-77 |
| Thermal Resources, Inc. | 1,320.00 | T. 25 S., R. 19 W. | 1-07-77 |
| Earth Power Corp. | 533.68 | T. 26 S., R. 19 W. | 12-28-76 |
| Lamar Hunt | 2,560.00 | T. 28&29 S., R. 2 W. | 5-29-75 |
| W. H. Hunt | 2,549.86 | T. 26 S., R. 1 W. | 5-29-75 |
| (Assignee) | 2,538.66 | T. 26 S., R. 1 W. | 5-29-75 |
| | 2,492.96 | T. 26 S., R. 2 W. | 5-29-75 |
| Nelson Bunker Hunt | 2,400.00 | T. 26 S., R. 2 W. | 5-29-75 |
| Hugo N. Schoellkopf, Jr. | 2,440.00 | T. 27 S., R. 2 W. | 5-29-75 |
| (Assignee) | 2,558.56 | T. 27 S., R. 2 W. | 5-29-75 |
| | 2,240.00 | T. 27 S., R. 2 W. | 5-29-75 |
| | 2,398.36 | T. 27&28 S., R. 2 W. | 5-29-75 |
| Nancy B. Hunt | 1,280.00 | T. 28 S., R. 2 W. | 5-29-75 |
| Nelson Bunker Hunt | 2,494.92 | T. 26 S., R. 2 W. | 5-29-75 |
| (Assignee) | 2,551.72 | T. 26 S., R. 2 W. | 5-29-75 |
| | 2,384.78 | T. 26 S., R. 2 W. | 5-29-75 |
| | 2,400.00 | T. 26 S., R. 2 W. | 5-29-75 |
| | 1,935.25 | T. 26 S., R. 2 W. | 5-29-75 |
| | 2,474.41 | T. 26 S., R. 1&2 W. | 5-29-75 |
| Chevron Oil Co. | 640.00 | T. 27 S., R. 20 W. | 12-28-76 |
| Phillips Petroleum Co. | 2,527.36 | T. 27 S., R. 1 E. | 5-27-77 |
| | 2,544.80 | T. 27 S., R. 1 E. | 5-27-77 |
| Sun Oil Co. (Delware) | 1,453.84 | T. 15 N., R. 3 W. & T. 15 N., R. 4 W. | 7-28-77 |
| | 83.48 | T. 15 N., R. 3 W. | 8-19-77 |

TABLE 6

FEDERAL COMPETITIVE GEOTHERMAL LEASES

AS OF APRIL 21, 1978

| LESSEE | ACRES | TOWNSHIP & RANGE | DATE ISSUED |
|---|---|---|---|
| Anadarko | 1,919.52 | T. 27 S., R. 1 W. | 6-26-75 |
| | 2,246.63 | T. 27 S., R. 1 W. | " |
| | 1,943.72 | T. 27 S., R. 1 W. | " |
| | 1,280.00 | T. 27 S., R. 1 W. | " |
| | 2,560.00 | T. 27 S., R. 1 W. | " |
| | 1,950.08 | T. 27 S., R. 1 W. | " |
| | 1,916.32 | T. 28 S., R. 1 W. | " |
| | 2,089.84 | T. 28 S., R. 1 W. | " |
| | 2,570.34 | T. 28 S., R. 1 W. | " |
| Earth Power Corp. | 1,885.42 | T. 24 S., R.19 W. | 9-2-76 |
| Amax Exploration, Inc. | 2,239.47 | T. 25 S., R.19 W. | 8-12-76 |
| Amax Exploration, Inc. | 1,686.98 | T. 18 N., R. 4 E. | 7-18-77 |
| | 2,183.86 | T. 18 N., R. 4 E. | 7-19-77 |
| Amax Exploration, Inc. | 1,108.50 | T. 21 N., R. 4 E. | 7-19-77 |
| Amax Exploration, Inc. | 963.47 | T. 21 N., R. 4 E. | 7-19-77 |
| | 2,118.22 | T. 21 N., R. 5 E. | 7-19-77 |
| Amax Exploration, Inc. | 1,993.26 | T. 21 N., R.3&4E. | 11-30-77 |
| Phillips Petroleum Co. | 2,560.00 | T. 25 S., R.19 W. | 9-2-76 |
| | 2,338.37 | T. 25 S., R.19 W. | 9-2-76 |
| Phillips Petroleum Co. | 1,362.65 | T. 18 N., R. 3 E. | 6-28-77 |
| Phillips Petroleum Co. | 1,702.05 | T. 18 N., R. 3 E. | 6-28-77 |
| | 2,024.95 | T. 18 N., R. 3 E. | 6-28-77 |
| Aminoil USA, Inc. | 1,235.72 | T. 25 S., R.19 W. | 12-2-76 |
| | 1,271.64 | T. 25 S., R.19 W. | 12-2-76 |
| Aminoil USA, Inc. | 2,088.95 | T. 18 N., R. 3 E. | 7-25-77 |
| Aminoil USA, Inc. | 1,665.80 | T. 19 N., R. 3 E.& T. 20 N., R. 3 E. | 7-25-77 |
| Aminoil USA, Inc. | 1,114.33 | T. 20 N., R. 3 E. | 7-25-77 |
| Aminoil USA, Inc. | 1,235.45 | T. 21 S., R. 1 W. | 1-5-78 |
| | 2,177.14 | T. 19&20,R. 2&3E. | 1-5-78 |
| | 1,685.00 | T. 20 N., R. 3 E. | 1-5-78 |
| | 1,719.50 | T. 20 N., R. 3 E. | 1-5-78 |
| Aminoil USA, Inc. | 2,390.02 | T. 3 S., R. 1 W. | 4-4-78 |
| Aminoil USA, Inc. | 661.25 | T. 3 S., R. 1 W. | 4-4-78 |
| Aminoil USA, Inc. | 2,046.85 | T. 3&4S., R. 1 W. | 4-4-78 |
| Aminoil USA, Inc. | 1,920.00 | T. 3 S., R. 1 W. | 4-4-78 |
| Chevron USA, Inc. | 1,003.41 | T. 21 S., R. 1 W. | 1-11-78 |
| Chevron USA, Inc. | 224.19 | T. 21 S., R. 1 W. | 1-11-78 |
| Texaco, Inc. | 1,158.90 | T. 21 S., R. 1 W. | 11-30-77 |
| Sunoco Energy Development Co. | 2,072.99 | T. 4 S., R. 1 W. | 2-14-78 |
| | 2,565.08 | T. 3&4S., R. 2 W. | 2-14-78 |

TABLE 7

STATE OF NEW MEXICO GEOTHERMAL LEASES

| LESSEE | COUNTY | ACRES | DATE ISSUED |
|---|---|---|---|
| Amax Exploration, Inc. | Sandoval | 29.30 | 12-29-75 |
| Amax Exploration, Inc. | Hidalgo | 2,540.47 | 12-29-75 |
| Amax Exploration, Inc. | Hidalgo | 320.00 | 12-15-77 |
| " " " | " | 320.00 | 08-14-74 |
| " " " | " | 120.00 | 08-14-74 |
| " " " | " | 160.00 | 08-14-74 |
| " " " | " | 320.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 80.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 636.20 | 08-14-74 |
| " " " | " | 636.28 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 480.00 | 08-14-74 |
| " " " | " | 263.64 | 08-14-74 |
| " " " | " | 526.92 | 08-14-74 |
| " " " | " | 320.00 | 08-14-74 |
| " " " | " | 480.00 | 08-14-74 |
| " " " | " | 160.00 | 08-14-74 |
| " " " | " | 400.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 280.00 | 08-14-74 |
| " " " | " | 400.00 | 08-14-74 |
| Jack A. Grimm | Dona Ana | 640.00 | 09-15-77 |
| Calvert Geothermal Res., Inc. | Hidalgo | 760.00 | 11-15-77 |
| " " " " | " | 278.66 | 11-15-77 |
| " " " " | " | 1,180.44 | 11-15-77 |
| " " " " | " | 729.99 | 11-15-77 |
| " " " " | " | 440.00 | 11-15-77 |
| " " " " | " | 122.28 | 11-15-77 |
| " " " " | " | 640.00 | 09-18-73 |
| " " " " | " | 1,271.84 | 09-18-73 |
| Chevron USA, Inc. | Dona Ana | 639.36 | 08-14-74 |
| Fogelson, E E | Dona Ana | 240.00 | 08-14-74 |
| " " " | Sierra | 640.00 | 08-14-74 |
| " " " | " | 160.00 | 08-14-74 |
| " " " | " | 160.00 | 08-14-74 |
| " " " | " | 320.00 | 08-14-74 |
| " " " | Socorro | 640.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | Sandoval | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| Aminoil USA, Inc. | Grant | 400.31 | 08-14-74 |
| " " " | " | 360.00 | 08-14-74 |
| " " " | " | 160.00 | 08-14-74 |
| " " " | " | 120.00 | 08-14-74 |
| " " " | " | 480.00 | 08-14-74 |
| " " " | " | 320.00 | 08-14-74 |

| | | | | |
|---|---|---|---|---|
| Aminoil USA, Inc. | Grant | 320.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | Hidalgo | 640.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 320.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 480.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 637.72 | 08-14-74 |
| " " " | " | 40.00 | 08-14-74 |
| " " " | " | 480.00 | 08-14-74 |
| " " " | " | 40.00 | 08-14-74 |
| " " " | " | 441.79 | 08-14-74 |
| " " " | " | 160.00 | 08-14-74 |
| " " " | " | 40.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 160.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | " | 40.00 | 08-14-74 |
| " " " | " | 520.00 | 08-14-74 |
| " " " | " | 640.00 | 08-14-74 |
| " " " | Grant | 40.00 | 03-12-75 |
| " " " | " | 440.00 | 03-12-75 |
| " " " | " | 162.89 | 03-12-75 |
| " " " | " | 87.16 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 120.00 | 03-12-75 |
| " " " | " | 403.52 | 03-12-75 |
| " " " | " | 82.06 | 03-12-75 |
| " " " | " | 200.00 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| " " " | Hidalgo | 560.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 158.11 | 03-12-75 |
| " " " | " | 403.04 | 03-12-75 |
| " " " | " | 160.00 | 03-12-75 |
| " " " | " | 200.00 | 03-12-75 |
| " " " | " | 480.00 | 03-12-75 |
| " " " | " | 637.40 | 03-12-75 |
| " " " | " | 200.00 | 03-12-75 |
| " " " | " | 80.00 | 03-12-75 |
| " " " | " | 160.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| " " " | " | 160.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |

| | | | |
|---|---|---|---|
| Aminoil USA, Inc. | Hidalgo | 640.00 | 03-12-75 |
| " " " | " | 480.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| Wolter, Emmet E. | " | 640.00 | 08-14-74 |
| " " " | " | 642.08 | 08-14-74 |
| " " " | " | 80.00 | 08-14-74 |
| " " " | " | 320.00 | 08-14-74 |
| Antweil, Alan J. | Rio Arriba | 585.52 | 08-14-74 |
| Supron Energy Corp. | Grant | 640.44 | 03-12-75 |
| " " " | " | 80.00 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| " " " | " | 161.46 | 03-12-75 |
| " " " | " | 160.00 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| " " " | " | 599.44 | 03-12-75 |
| " " " | " | 200.00 | 03-12-75 |
| " " " | " | 160.00 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| " " " | " | 400.00 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| " " " | " | 120.00 | 03-12-75 |
| " " " | " | 420.83 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 407.17 | 03-12-75 |
| " " " | " | 40.00 | 03-12-75 |
| The Cherokee & Pittsburg Coal & Mining | Sandoval | 640.00 | 03-12-75 |
| " " " " | " | 640.00 | 03-12-75 |
| " " " " | " | 644.08 | 03-12-75 |
| " " " " | " | 640.00 | 03-12-75 |
| " " " " | " | 589.11 | 03-12-75 |
| " " " " | " | 640.00 | 03-12-75 |
| " " " " | " | 640.00 | 03-12-75 |
| Kelly, John M. | Socorro | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 64.27 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| Covello, J. W. | " | 640.00 | 03-12-75 |
| Gulf Oil Corp. | " | 550.56 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |
| " " " | " | 320.00 | 03-12-75 |
| " " " | " | 640.00 | 03-12-75 |

TABLE 3

GEOTHERMAL DEVELOPERS/LESSEES/UTILITIES IN NEW MEXICO

Amax Exploration, Inc.
Aminoil USA, Inc.
Anadarko Oil Company
Calvert Geothermal Resources, Inc.
The Cherokee & Pittsburg Coal & Mining
Chevron Oil Company
Deuterium Geothermal Corporation
Earth Power Corporation
Fogelson, E.E.
Grimm, Jack F.
Gulf Oil Company
Hunt Energy Company
Kelly, John M.
Oxy Petroleum Company
Public Service Company of New Mexico
Phillips Petroleum Company
Sun Oil Company (Delware)
Supron Energy Corporation
Texaco, Inc.
Thermal Resources, Inc.
U.S. Geothermal Corporation
Union Oil Co. of California
Walter, Emmet E.
Wright, Hoover

## GEOTHERMAL LEASING PROCEDURES

### Private Land

There are no statutes or regulations specifically concerning geothermal leases of private land. Therefore, any such lease could be obtained by direct negotiation with the owner of the geothermal resources. Determination of the owner is often difficult since much of New Mexico's land has been sold with the reservation of mineral rights in a previous owner. In any event, once the owner of the geothermal resources has been determined and located, and the lease negotiated, then a copy of the lease must be filed with the county clerk for the county or counties in which the land is located.

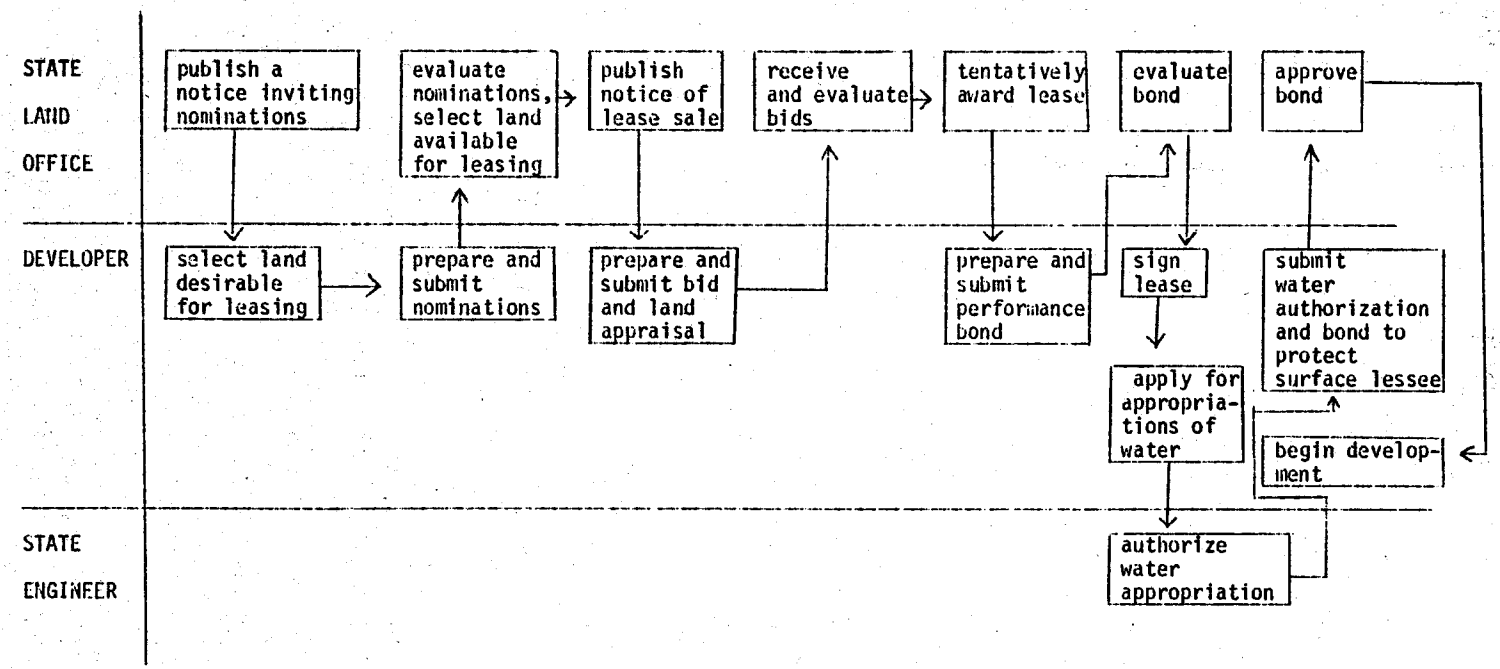
### State Land

Geothermal leases of state land are controlled by the Geothermal Resources Act, discussed above, and rules and regulations adopted by the Commissioner of Public Lands pursuant to that act. Initial procedures for obtaining a geothermal lease depend upon the status of the specific land desired for leasing. If the land is under the jurisdiction of a stage agency other than the Commissioner of Public Lands or under the jurisdiction of a school district, then application for the lease cannot be made until the agency or school district has requested that the Commissioner make the land available for leasing. Likewise, if the land surface has been sold by the state prior to 1967 with mineral rights (but not geothermal rights) reserved to the state, then the surface patentee or contract purchaser must first be consulted. If the land has been classified by the Commissioner as a "known geothermal resources field", then a base can be obtained only by competitive bidding at a public auction. Also, land withheld for other reasons may not be subject to leasing. A developer can determine the land status by checking the tract books of the State Land Office.

The Geothermal Resources Act gives the Commissioner broad powers in issuing geothermal leases. Under the act, he may withhold any land from leasing and may reject any application for a lease at any time before a lease is issued. He also has the power to require competitive bids for leases or may issue leases on merely a priority of application basis. By Order No. 1-1974, the Commissioner has ruled that all applications for geothermal leases will be rejected and that such leases will only be obtainable through competitive bidding. Therefore, since the date of that order (March 26, 1974) all state lands have been withheld from priority leasing and are leased only by competitive bidding at a public auction.

The procedures for obtaining a lease are shown in Figure 4. The Commissioner initiates a lease sold by publishing a notice asking for nominations that certain land be obtainable for leasing. Pursuant to the notice, a developer will determine what land he desires to lease and the status of the land and will submit a nomination for that land to the Commissioner. Upon receipt of the nominations, the Commissioner evaluates the land nominated in order to determine which tracts of land will bring the maximum benefit to his trust beneficiaries. After such determinations, he will publish a notice that the tracts of land are available for geothermal leasing by competitive bidding. Application for a lease is made upon forms prescribed by the Commissioner and must be accompanied by an application fee, the first year's rental, the bonus offered and an appraisal of the value of the land for geothermal lease purposes.

Figure 5. Geothermal Leasing Procedure for State Lands



The lease is awarded to the developer offering the highest bonus.

No lease may be issued until a performance bond is filed with the Commissioner to guarantee payment of royalties. The amount of royalties is specified in the lease but may be waived, or reduced by the Commission in order to promote development. Leases are for an initial term of five years with a right to renew for another five years. They also are assignable and may be used for collateral security. After a lease is issued, the Commissioner retains a broad power over geothermal development and protection of both surface and subsurface resources.

No geothermal lessee of state lands may begin operations until he has filed a bond with the Commissioner in order to protect the surface lessee. Also, if the geothermal lessee plans to appropriate water for use in geothermal development, then no operations may be commenced until a copy of a written authorization from the State Engineer to appropriate water is filed with the Commissioner.

Federal Land

The foundation of the federal geothermal leasing program is the Geothermal Steam Act of 1970. The act authorizes the Secretary of Interior to dispose of federal lands to develop geothermal steam found within the public, withdrawn and acquired lands, as well as land that has been conveyed subject to the reservation of mineral rights. The act provides two primary ways to obtain leases: competitive bid sales, and non-competitive applications. A non-competitive lease is free except for certain procedural expenses such as filing fees. A bonus fee is required to obtain a lease in competitive sale. Whether or not competitive bidding occurs depends if the land is located within a Known Geothermal Resource Area (KGRA).

A third way to obtain a geothermal lease is to convert an interest previously obtained under other statutes such as the Mineral Land Leasing Act of 1920. This "grandfather" right was rather controversial during the legislative evolution of the 1970 act.

The Department of Interior has assigned the responsibility for geothermal leasing to two agencies, the Bureau of Land Management and the U.S. Geological Survey. The BLM has the authority to issue and enforce leases, while the U.S.G.S. manages the actual lease operations. This division of responsibility is similar to the arrangements in other leasing programs.

The 1970 act provides for a preliminary lease term of ten years, but the lessee may obtain an extension of up to forty years by achieving production of steam in commercial quantities. After this term expires, the lessee has a preferential right to renew for additional forty year terms. A five year extension of the original ten year primary term is available if the lessee is diligently engaged in drilling operations when the tenth year ends. The 1970 act states that royalties must not be less than ten percent or more than fifteen percent of the value of the steam or any other form of heat or energy. The 1970 act also establishes an annual rental payment of not less than one dollar per acre.

### Indian Land

Ownership of Indian lands is theoretically vested in the federal government. Therefore, any geothermal lease is between the United States and the developer, with the tribe consenting to the lease and receiving royalty benefits. However, in actual practice, geothermal leases are obtained by direct negotiation between the developer and the applicable Indian tribe. After the lease agreement has been made, it is then submitted to the Secretary of Interior or his designee, usually the BIA supervisor of the particular tribe, for his approval.

## STATE REGULATORY AUTHORITY

### Oil Conservation Division

Primary responsibility over geothermal development rests with the Oil Conservation Division under the authority of the Geothermal Resources Conservation Act. The Commission has broad authority under the act to prevent waste and protect correlative rights and has adopted extensive regulations to exercise its authority.

Under the act and its regulations, the Division requires bond, permits and comprehensive reports to be submitted by developers and may regulate virtually all aspects of development and production. The jurisdiction of the Oil Conservation Division applies to all geothermal developments on private or state lands and applies to leases on federal land to the extent that such jurisdication is not inconsistent with United States regulations.

### Energy and Minerals Department

The Energy and Minerals Department has broad powers concerning all aspects of energy development within New Mexico. The Department is composed of the Energy Resources Development Division, Mining and Minerals Division, Energy Conservation and Management, and Oil Conservation Division. Its duties include maintaining complete records of energy activity in the state and it may subpoena records and individuals. As noted above, specifically concerning geothermal development, Energy & Minerals Department has the power to review the decisions of the Oil Conservation Division. Also, every producer must notify the Division within five days of the completion of any well capable of producing geothermal energy in commercial quantities.

### State Engineer

In addition to the regulatory functions of the Oil Conservation Division of the Energy & Minerals Department, any developer desiring to drill a geothermal well within a declared underground basin from which water as a gas or liquid, will be withdrawn must first obtain a permit from the State Engineer to drill and appropriate the geothermal resources. New Mexico statutes and regulations promulgated by the State Engineer set forth the procedures necessary to obtain

a permit to appropriate water, as well as license requirements for well drillers. The construction, repair and plugging of water wells are also regulated by the State Engineer.

State Land Commissioner

As discussed above, any geothermal development on state land is also subject to the jurisdiction of the State Land Commissioner. The Commissioner retains a large amount of control over surface and subsurface conditions, as well as production, even after the issuance of a lease.

Environmental Improvement Division

The Environmental Improvement Division of the Health and Environment Department, is responsible for environmental management and protection throughout the state. Concerning geothermal development, the Division has regulatory authority over air quality, radiation control, noise control and occupational health and safety. The Environmental Improvement Division also serves as the staff for the Water Quality Control Commission which regulates aspects of water quality. Neither the Environmental Improvement Division nor the Water Quality Control Commission has yet enacted regulations specifically relating to geothermal development.

## GEOTHERMAL RESOURCE ASSESSMENT AND SCENARIO DEVELOPMENT

The chief objective of this project has been to develop and refine site-specific scenarios for all potential geothermal resources in the state.

These geothermal resource areas were identified by studying the records of geothermal leases on public lands obtained from state and federal agencies. Subsequently, discussions were held with lease holders to learn about the current status and future plans. Additional information and ideas for future development plans were gleaned through various publications and conversations with community groups and potential users. These publications included catalogs of hot springs and wells, pertinent geophysical data, and documents on historical geologic activity.

The information was complied and interpreted into the standard format of General Description, Site Map, Resource Characteristics, Development Status and Activity, Serious Development Problems and Development Schedule. The resource areas were organized into categories in order to simplify the scenario preparation (see Table 9). Only for those sites in which there has been considerable activity and interest, has a development schedule been predicted. The following sites with significant leasing and development have been processed:

Albuquerque
Animas (Lightning Dock)
Jemez Springs
Kilbourne Hole
Las Alturas
Ojo Caliente
Radium Springs
San Ysidro
Socorro
Truth or Consequences
Valles Caldera

TABLE 9

GEOTHERMAL RESOURCE DEVELOPMENT SCHEDULE CATEGORIES

JULY 1978

1. Significant Commercial Activity -
   Baca Location No. 1 (Valles Caldera)

2. Activity - Leases or Development
   A. Possible Power Generation Sites:
      Animas (Lightning Dock)
      Kilbourne Hole
      San Ysidro
      Radium Springs
      Socorro

   B. Possible Direct Application (Low and Moderate Temperature):
      Jemez Springs
      Animas
      Ojo Caliente
      Faywood
      Socorro
      Radium Springs
      Los Alturas

3. No Activity or Interest
   A. High Potential:
      Cliff-Gila-Riverside
      Albuquerque Basin
      Gila Hot Springs
      Truth or Consequences
      Tularosa Basin
      Anthony - Mesquite
      Lower San Francisco H.S.

   B. Moderate Potential:
      Playas
      Rincon
      Montezuma
      Jornada del Muero
      Hueco - S. Tularosa
      Las Palomas
      Mamby H.S.
      Deming
      Mimbres H.S.
      West Mesa

   C. Low Potential:
      Ponce de Leon
      Aleman
      Closson
      Crownpoint
      Derry
      White Sands

TABLE 10

NEW MEXICO HIGH-TEMPERATURE RESOURCE PROSPECTS[a]

| | Lat. | Long | T surface (°C) | T $SiO_2$ (°C) | T NaKCa (°C) | T subsurface (°C) |
|---|---|---|---|---|---|---|
| Areas Sampled: | | | | | | |
| Baca Location No. [b] | 35°43' | 106°32' | 87 | 177 | 234 | 240 |
| Lightning Dock[b] | 32°08.5' | 108°50' | 99 | 160 | 167 | 170 |
| Guadulape Area | 35°30' | 107°15' | 35 | 156 | 177 | 170 |
| Columbus Area | 31°45' | 107°30' | 31 | 135 | 195 | 155[c] |
| Kilbourne Hole[b] | 31°45' | 106°50' | 28 | 133 | 200 | 155[c] |
| Lower Frisco H.S.[b] | 33°15' | 108°47' | 49 | 132 | 148 | 150 |
| Radium Springs [b] | 32°30' | 106°55.5' | 50 | 118 | 223 | 130[c] |
| Mamby's H.S. | 36°31.6' | 105°40.6' | 41 | 116 | 168 | 125[c] |
| San Diego Mountain | 32°38' | 106°58' | warm | 105 | 233 | 125[c] |
| Mesquite-Berino | 32°10.0' | 106°40.0' | 31 | 112 | 175 | 120[c] |
| Las Alturas | 32°15.0' | 106°46.0' | 43 | 109 | 179 | 120[c] |
| Truth or Consequences | 33°08.1' | 107°15.2' | 45 | 96 | 180 | 100[c] |
| Derry Spring | 32°47.6' | 107°16.6' | 33 | 83 | 156 | 100[c] |
| Areas from WATSTORE: | | | | | | |
| Southern Tularosa Basin | 32°05' | 106°05' | 71 | -- | -- | 150 |
| White Sands (Town) | 32°25' | 106°25' | 54 | 114 | 160 | 150 |
| North of Socorro | 34°20' | 106°50' | 41 | 110 | 166 | 150 |
| Prewitt Area | 35°26' | 107°53.0' | 46 | 100 | 200 | 150 |
| Jemez Reservoir | 35°20' | 106°40' | warm | 120 | 150 | 150 |
| Lordsburg | 32°13.7' | 108°30.7' | 33 | 91 | 151 | 150 |

[a] Source: Swanberg, 1978

[b] KGRA

[c] Estimated subsurface temperature in the 150-200°C range if mixing models are applied to the silica data.

TABLE 11

NEW MEXICO LOW-AND MODERATE-TEMPERATURE RESOURCE PROSPECTS[a]

| | Lat. | Long | T surface (°C) | T $SiO_2$ (°C) | T NaKCa (°C) | T subsurface (°C) |
|---|---|---|---|---|---|---|
| Ojo Caliente | 36°18.3' | 106°03.0' | 56 | 122 | 161 | 130 |
| Montezuma H.S. | 35°39.2' | 105°17.4' | 59 | 122 | 140 | 130 |
| Ponce de Leon | 36°19.4' | 105°36.5' | 34 | 106 | 92 | 105 |
| San Ysidro[b] | 35°35' | 106°51' | 52 | 89 | 160 | 100 |
| Turkey Creek H.S. | 33°06.5' | 108°23.0' | 74 | 117 | 68 | L.T. |
| Gila H.S.[b] | 33°10' | 108°10' | 66 | 129 | 77 | L.T. |
| Closson | 35°15.5' | 108°19.4' | 61 | 95 | 51 | L.T. |
| Fort Wingate | 35°30' | 108°35' | 61 | -- | -- | L.T. |
| Mimbres H.S. | 32°44.9' | 107°50.1' | 58 | 107 | 75 | L.T. |
| Faywood H.S. | 32°33.3' | 107°59.7' | 54 | 97 | 78 | L.T. |
| Tohatchi | 35°55.3' | 108°34.7' | 39 | 66 | 82 | L.T. |
| San Francisco H.S. | 33°49.8' | 108°47.9' | 37 | 97 | 52 | L.T. |
| Crown Point | 35°41.6' | 108°08.4' | 37 | 60 | 80 | L.T. |
| E. San Augustin Plain | 34°00.5' | 108°05.5' | 35 | 108 | 53 | L.T. |
| Socorro[b] | 34°05.0' | 106°57.0' | 34 | 61 | 72 | L.T. |
| Garton Well | 32°46.8' | 106°09.9' | 34 | 63 | 100 | L.T. |
| Cliff Area | 32°52.6' | 108°35.0' | 31 | 35 | 53 | L.T. |
| Albuquerque Area | 35°05' | 106°45' | 30 | -- | -- | L.T. |

[a] Source: Swanberg, 1978,
[b] KGRA

## ALBUQUERQUE WBS 7061

### General Description

Albuquerque lies in the Rio Grande rift, which is recognized as one of the major geothermal resource areas in the United States. Although there are no hot springs or similar surface manifestations in the immediate vicinity of the city, the proximity of young volcanoes, abnormal temperatures in nearby water and oil wells, and high heat flow to the west of the city testify to a yet undetermined resource. A type of geothermal direct thermal application is currently operating in the Sandia Savings Building in Albuquerque where two wells are used for supplying cool and warm waters for the heating and cooling systems.

A substitution of geothermal energy for space heating, water heating, cooling, industrial processing, etc. could satisfy a large portion of Albuquerque's projected development. This development is planned to the west of the current urban area into the region considered to be of higher geothermal potential.

Some wells drilled on the West Mesa have warm temperatures ($83^{o}$-$88^{o}$F.) but whether these temperatures increase to useable levels with increasing depth will be determined in the near future.

### 30.3 Development Status and Activity

Currently, there is no leasing, drilling, or exploration. A proposed project by an UNM geophysicist will hopefully provide a thorough evaluation of the resource potential.

### 30.4 Severe Development Problems

None are anticipated.

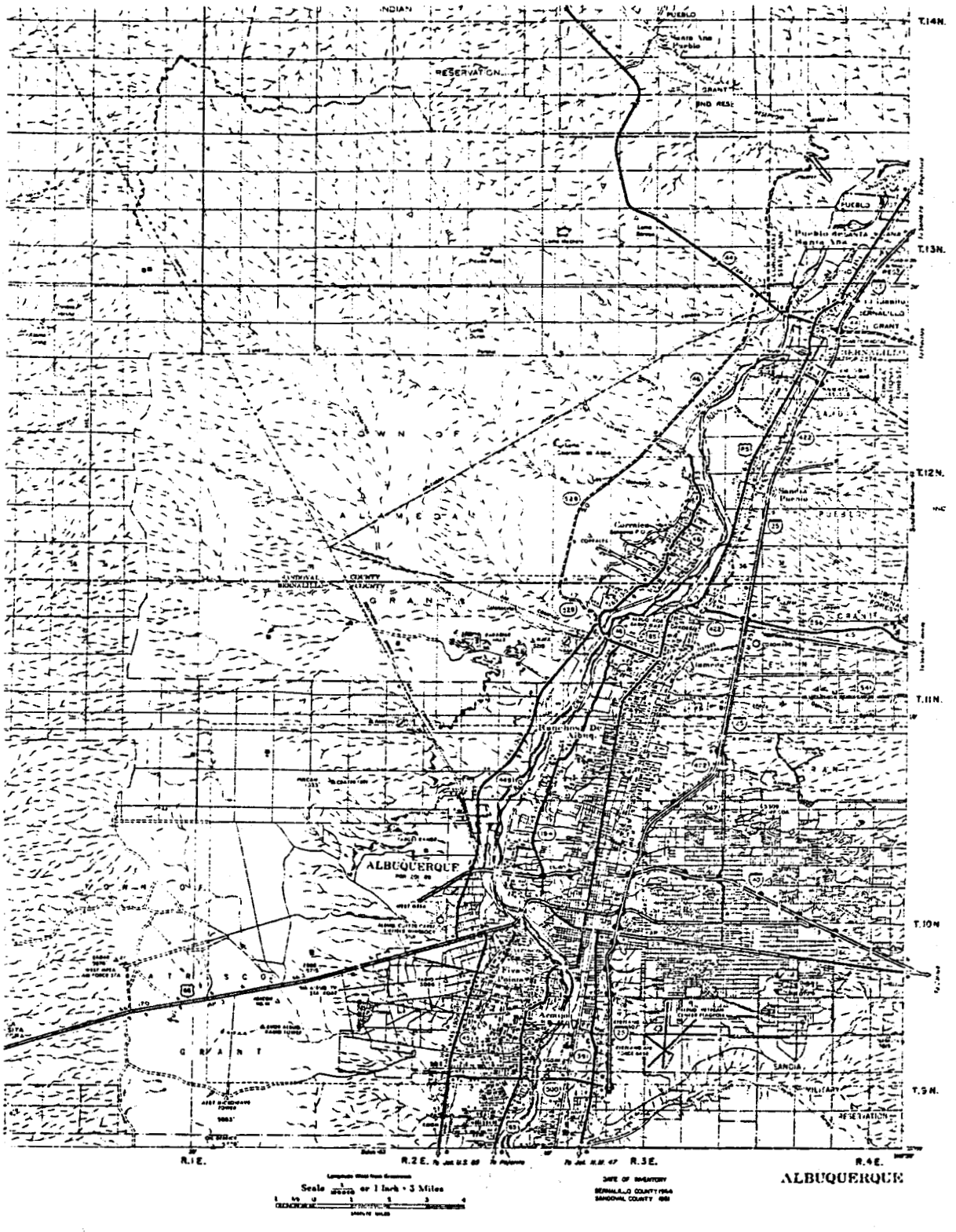



Figure 6. Albuquerque Geothermal Resource Area

## General Description

The Animas Valley area is located in central Hidalgo County in the extreme southwestern corner of the state. It is situated south of Interstate 10 and includes the Villages of Cotton City and Animas. Both villages have a population of less than 200 and heating needs are served by propane, butane, and natural gas.

The nearest town, lordsburg, has a population of 5,200 and it is six miles northeast of the valley. At Lordsburg, the Community Public Service Company operates a 55 MW power generating plant which uses primarily natural gas and small quantities of oil. Conceivably, CPS could be the potential utility for geothermal power generation.

The land in this valley is somewhat evenly divided among the state, federal, and private ownerships and is used for ranching and irrigated farming.

The best potential users of geothermal energy are the area residents who are very enthused and receptive to geothermal development particularly, direct-thermal use. According to what is known, the largest geothermally-heated greenhouse in the United States is located here with 100,000 sq. ft. of space for vegetables and crops. The heat source are the "section 7 hot wells" first drilled in 1948 and located near the community of Cotton City. The Animas Valley resource area also includes the Lightning Dock KGRA.

The Hidalgo County Farmer Coop has recently petitioned the Southwestern New Mexico Resource, Conservative, and Development Council for a feasibility study for a major geothermal dehydration plant. In July of 1978, the New Mexico Energy and Minerals Department funded a NMSU R & D project that will include a study of geothermal crop-drying. This research program is called, "Use of Geothermal for Agribusiness Development in Southwestern New Mexico." One important objective will be to design agricultural processing equipment and determine the cost of using geothermal water. This hopefully will assist the local farmers in achieving their goal in geothermal chil-pepper drying plants.

### 30.2 Resource Characteristics - LIGHTNING DOCK (ANIMAS)

Surface Fluid Temperature: $99^{0}C$ in 95 foot well

Subsurface Fluid Temperature: $170^{0}C$

Total Dissolved Solids: 1120 ppm

Estimated Energy Potential: Inferred: 100 MW/30 years
Indicated: 20 MW/30 years

Type of Overlying Rock: Alluvium over tertiary volcanics

Estimated Depth from Top of Reservoir: Well struck steam at 88 feet

Estimated Size of Reservoir: 2.25 $km^3$

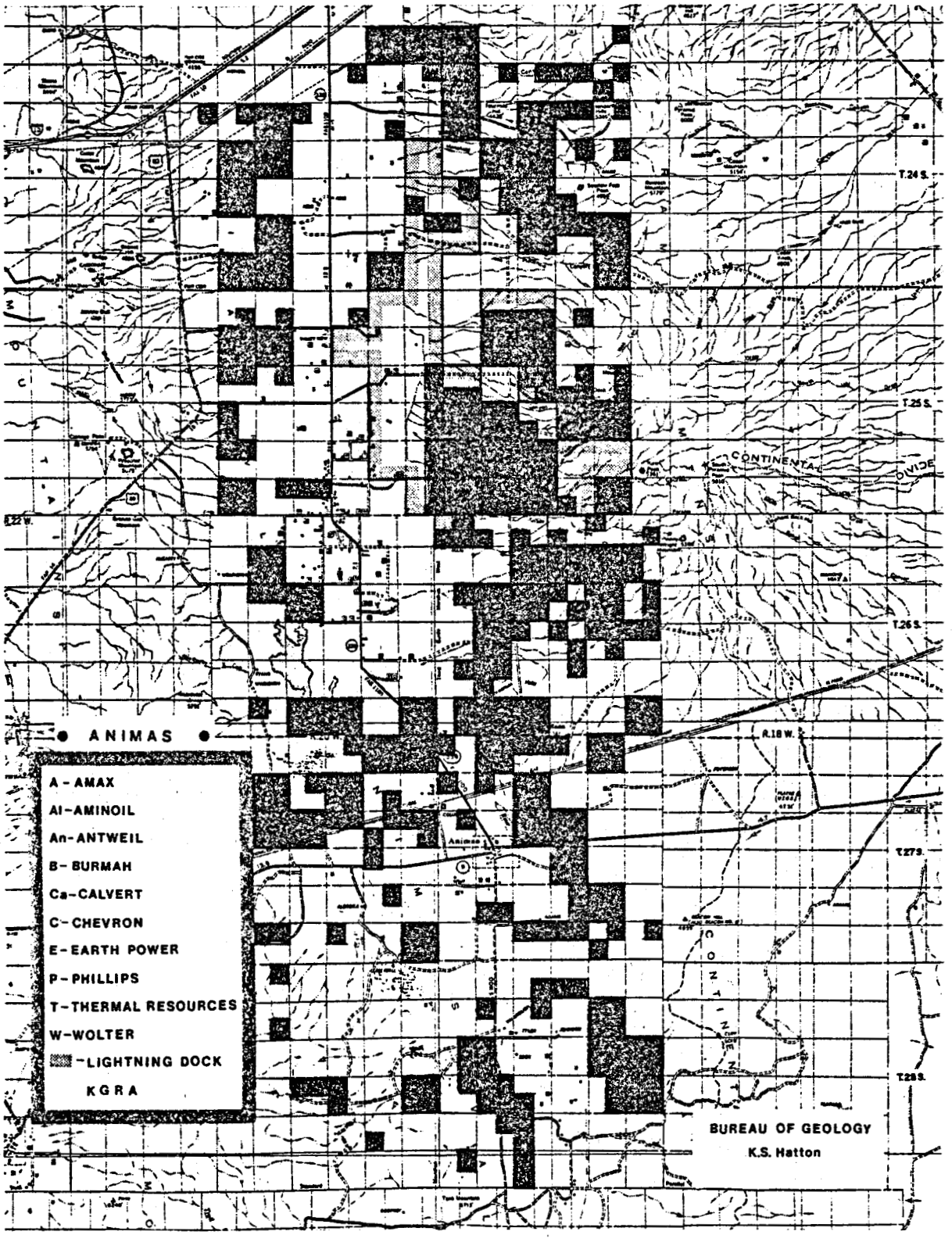



Figure 7. Animas Geothermal Resource Area

Site Location: T.25S., R.19W., Section 7

Latitude: $32^{o}$ 8.5'N Longitude: $108^{o}$ 50.W

County: Hidalgo

Land Ownership: State, federal, private

Land Use: Ranching and irrigated farming

Description of KGRA: Parts of T.24 and 25S., R.19 and 22N. Totaling 23,552 acres

Leasing Status: About 43,000 acres of federal lands have been leased in and around the KGRA.

About 33,120 acres of state lands have been leased in and around the KGRA.

Within the KGRA there are 12 federal leases.

## 30.3 Development Status and Activity

The following companies have drilled or will be drilling temperature gradient holes:

| | |
|---|---|
| Aminoil | 14 |
| Chevron | 8 |
| Phillips | 19 |
| Amax | 17 |

Amax plans to reenter an old oil well to run temperature survey. Chevron will make a dipole-dipole survey. The main lease holders are Burmah O&G, Chevron, Amax, Calvert-Geothermal, Aminoil, Phillips and Geothermal Resources. Current drilling activity is concentrated in T.27S., R20W., (West of Animas) and in T.25S., R.19W., (East of Cotton City). Steam and hot water was discovered while drilling an irrigation well in T.25S., R.19W., Section 7. There are no hot springs in the area.

The geothermal reservoir has not been proven yet. However, there are already several non-electric applications. These involve the space-heating of two ranches which includes several greenhouses. The area farmers and ranchers hope to plan a geothermal crop-drying plant this summer.

## 30.4 Severe Development Problems

The geohydrologic studies seem to indicate extensive mingling of the groundwater by a local geothermal anomaly. Although the temperature of this resource is high ($170^{o}$C) the reservoir may be too limited for power generation unless extensive exploration indicate otherwise.

Despite the eagerness and enthusiasm shown by the area farmers and ranchers, they lack capital and direction to carry out plans they envision for crop-drying operations. Hopefully, the Hidalgo County Farmer's Coop will obtain the necessary incentives from all levels of government to exploit the geothermal resource.

## 30.5 Development Scenarios

Two scenarios, electric and direct use, were developed. The amount of power potential identified so far is quite low, at least 20 MW (electric). The inferred potential is 100 MW. Following the testing of the thermal gradient, the scenario will be adjusted according to the available information. The outlook for non-electric application is good, considering the attitude and planning of the local communities. One or more agricultural drying plants should be operational by 1980 or 1981.

# Table 12

POSTULATED SITE DEVELOPMENT SCHEDULE
ANIMAS VALLEY

WBS 7002

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Developer | Conducts casual reconnaissance exploration | ——— | ——— | | | | | | | | | | | |
| BLM, State | Leases Land | ——— | ——— | | | | | | | | | | | |
| USGS | Makes environment assessment | . 1975 | | | | | | | | | | | | |
| USGS, State | Approves plan of operation and issues permit to explore | – – | – – | | | | | | | | | | | |
| Developer | Conducts geophsical work and drills T.G. holes | – | ——— | ——— | | | | | | | | | | |
| USGS | Makes EA for drilling deep exploratory wells | | | ——— | ——— | | | | | | | | | |
| USGS, State | Gives permission to drill | | | | . | | | | | | | | | |
| Developer | Drill deep exploratory wells | | | | ——— | ——— | | | | | | | | |
| Developer | Conducts Feasibility Study | | | | | ——— | | | | | | | | |
| Developer | Water rights application with State Engineer | | | | | – | | | | | | | | |
| USGS | Makes EA for development | | | | | | ——— | | | | | | | |
| | Gives permission to develop | | | | | | . | | | | | | | |
| Developer | Drills development wells and runs production tests | | | | | | ——— | ——— | | | | | | |
| PSC | Certifies plant and site | | | | | | | ——— | | | | | | |
| | Issue permits | | | | | | | | . | | | | | |
| USGS | Approves plan of operation for production | | | | | | | ——— | ——— | | | | | |

POSTULATED SITE DEVELOPMENT SCHEDULE
ANIMAS VALLEY

WBS 7002

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Utility | Obtains R.O.W. for Power Line | | | | | | | | —— | | | | | |
| Utility | Plant Construction | | | | | | | | —— | —— | | | | |
| Utility | Puts power on line | | | | | | | | | | 20 MW △—— | 10MW △—— | —— | —— |

## JEMEZ SPRINGS WBS 7006

### General Description

The Jemez Springs area is centered around the hot springs in San Diego Canyon about two miles south of Soda Dam and twelve miles north of Jemez Pueblo. The population of the community is about 500 and it is entirely dependent on wood and propane for heating purposes. The several hot springs in this area have a top temperature of 169°F.

The present uses of geothermal energy involve a hot spring resort spa with bathhouses and swimming pools, and a greenhouse run by a Buddhist colony. The village, in conjunction with Coupland, Moran & Associates, have submitted a proposal to DOE for a district heating system in 1977. Unfortunately, the proposal was rejected. Nevertheless, the potential still remains for space heating, small agribusiness and wood products processing by geothermal energy. New plans for development are forthcoming soon. The development and use of geothermal energy would have an important effect on the economic development of the region.

The Jemez Springs area is bordered on the east side by the Baca Location No. 1 KGRA.

The San Diego Canyon, which includes Jemez Springs, is flanked on three sides by the Santa Fe National Forest situated on the volcanic uplands. Also, it is bordered on the east by the Baca Location No. 1 KGRA.

Soda Dam, a huge natural hot spring deposit, is also part of the geothermal area and is located one mile north of the village. The springs of this feature discharge at a maximum temperature of 115°F. These hot springs belong to the Forest Service and is used by the public for recreation. No commercial development is anticipated. However, the Forest Service, LASL, New Mexico Energy and Minerals Department, and the New Mexico Highway Department are all interested in restoring the dam and the spring flow to its original condition.

### 30.2 Resource Characteristics - JEMEZ SPRINGS

Surface Fluid Temperature: 73°C

Subsurface Fluid Temperature: 135°C

Total Dissolved Solids: 2100 ppm

Estimated Energy Potential: 12 MW centuries (thermal)
155.25 X $10^{15}$ calories

Type of Overlying Rock: Alluvium over Permian Sands and Shales

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 2.25 $km^3$ (assumed)

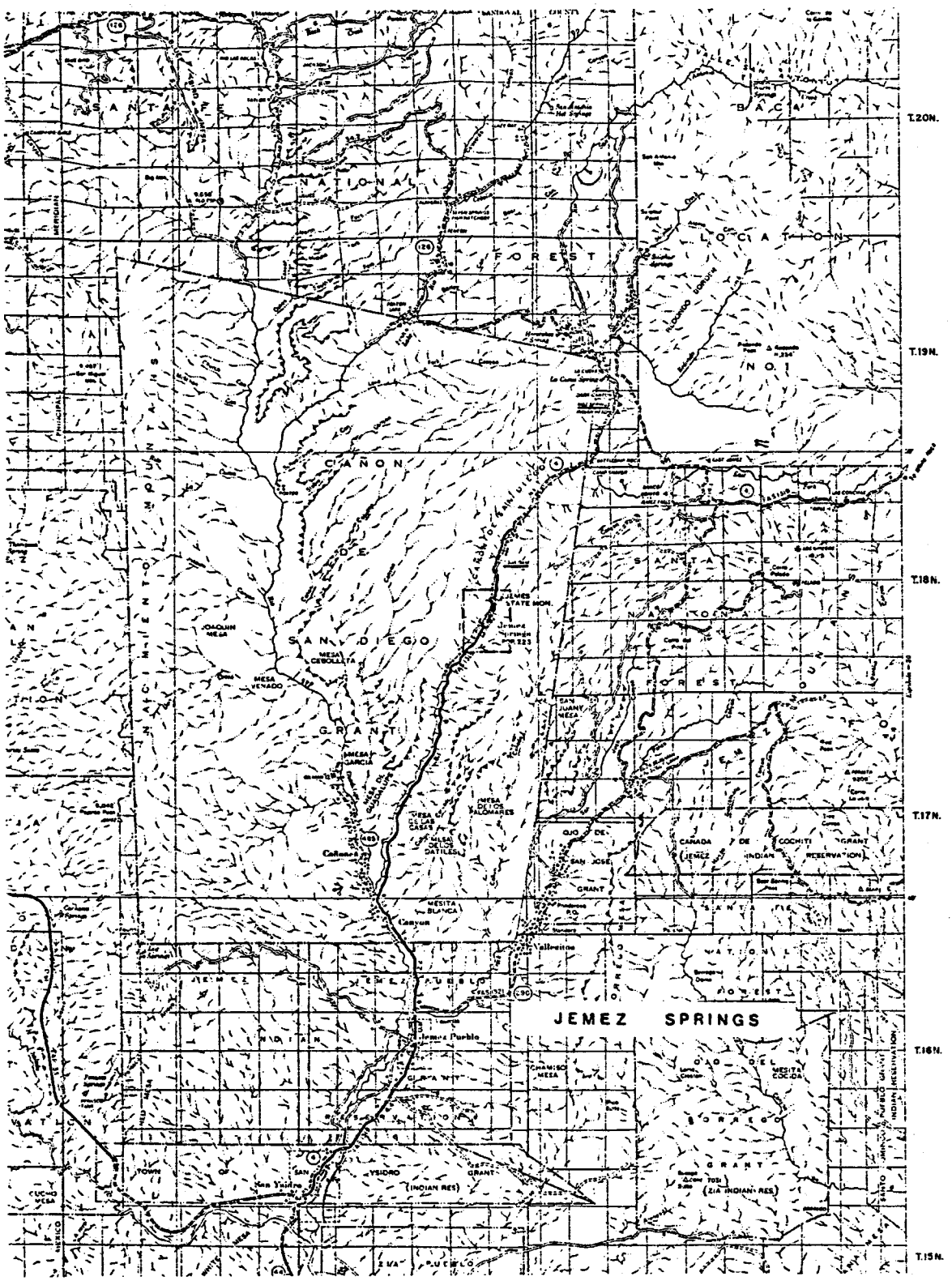



Figure 8. Jemez Springs Geothermal Resource Area

Site Location: T.18N., R.2E., Section 23

Latitude: $35^{o}$-47'N Longitude: $106^{o}$-4W

County: Sandoval

Land Ownership: Hot Springs is on village property. Village is located in Canon de San Diego grant.

Land Use: None

Description of KGRA: Baca Location No. 1, KGRA lies two miles to the East.

Leasing Status: Sun Oil controls most of the fee owned geothermal mineral rights in the San Diego grant, which includes T.17, 18, 19N., R.1&2E. This area lies immediately southwest of Baca Location No. 1.

Calvert Geothermal Resources filed on 7680 acres and Sun filed on 4000 acres of federal land in T.18N., R.2E. in January 1974. These blanket filings may pay off, since the ownership of the mineral rights is established.

East of Jemez Springs, in the lower part of the Baca Location #1 KGRA, T.18&19N., R.3&4E., the following hold leases, awarded at the competitive sale last May, (1977):

| | |
|---|---|
| Amax | 3871 acres |
| Phillips | 5089 acres |
| Aminoil | 2089 acres |

## 30.3 Development Status & Activity

Although no commercial development is taking place, the Village of Jemez Springs is optimistic on its potential. Last year, the engineering firm of Coupland, Moran & Associates, 200 Altez, S.E., Albuquerque, New Mexico, put together a proposal for a project to utilize the geothermal resources of the area for space heating and domestic heating of hot water for the Village of Jemez Springs. The project would cost $3,510,119.80, of which DOE would pay $3,142,373.50. The proposal was rejected by DOE San Francisco office, December 27, 1977. However, some modification of the project probably will surface this summer.

## 30.4 Severe Development Problems

It appears doubtful that the project proposed by Coupland, Moran & Associates will ever become a reality, unless most of it is funded by some government organization. Perhaps there would be an eventual pay out if agribusiness and wood products processing operation used the heat energy on a more or less continuous basis, perhaps, through cogeneration.

But first it must be determined if the resource exists in sufficient quantity. This can be determined only by drilling, which in itself can be a large expense. Once the resource is proven, perhaps capital will be attracted to utilize the heat.

The New Mexico Energy and Minerals Department is presently seeking a funding source to conduct the drilling phase of this program.

## KILBOURNE HOLE WBS 7004

### General Description

The Kilbourne Hole geothermal area is located in Dona Ana County south of Las Cruces, immediately west of the Rio Grande Valley; its southern and extends into Mexico. It is a large area of dry desolate country containing lava flows, cinder cones and widely scattered ranch houses.

Kilbourne Hole itself is a maar, a crater-like feature probably caused by steam explosion near the surface, resulting from groundwater coming into contact with a molten intrusive mass. There are several such crater-like depressions in the area, which along with the volcanics attest to a time of high geothermal activity.

The size of the heat source is unknown, but geochemically derived subsurface temperatures are as high as 200°C (Na-K-Ca geochemistry). The KGRA itself occupies 25,133 acres in townships twenty-seven and twenty-eight south, range 1 west. The land is mostly federally owned.

There has been considerable interest in the area, as demonstrated by the geophysical surveys and geothermal gradient holes drilled. Some of the major companies that hold leases and/or have active exploration programs in the area are Anadarko, Phillips, Petroleum, and the Hunt Energy Corporation.

Las Cruces and El Paso, both less than forty miles away, could provide a market for any electricity generated. El Paso Electric Company could conceivably be the potential utility in this area including the Rio Grande Valley which has a population of about 500,000. Direct use, such as heating or processing, may be possible in the Rio Grande Valley to the East, depending on the need and pipeline problems. The Valley is largely dependent on an agriculture economy with natural gas for energy. Any input by geothermal energy will greatly enhance the stability and growth of the economy.

Because there are no known reserves at this time, the potential energy there is estimated.

30.2 Resource Characteristics - KILBOURNE HOLE

Surface Fluid Temperature: 45°C - 83°C

Subsurface Fluid Temperature: 155°C

Total Dissolved Solids: 4900 ppm

Estimated Energy Potential: Inferred 50 MW for 30 years
Indicated 20 MW for 30 years

Type of Overlying Rock: Volcanic

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 3.5 $km^3$ (assumed)

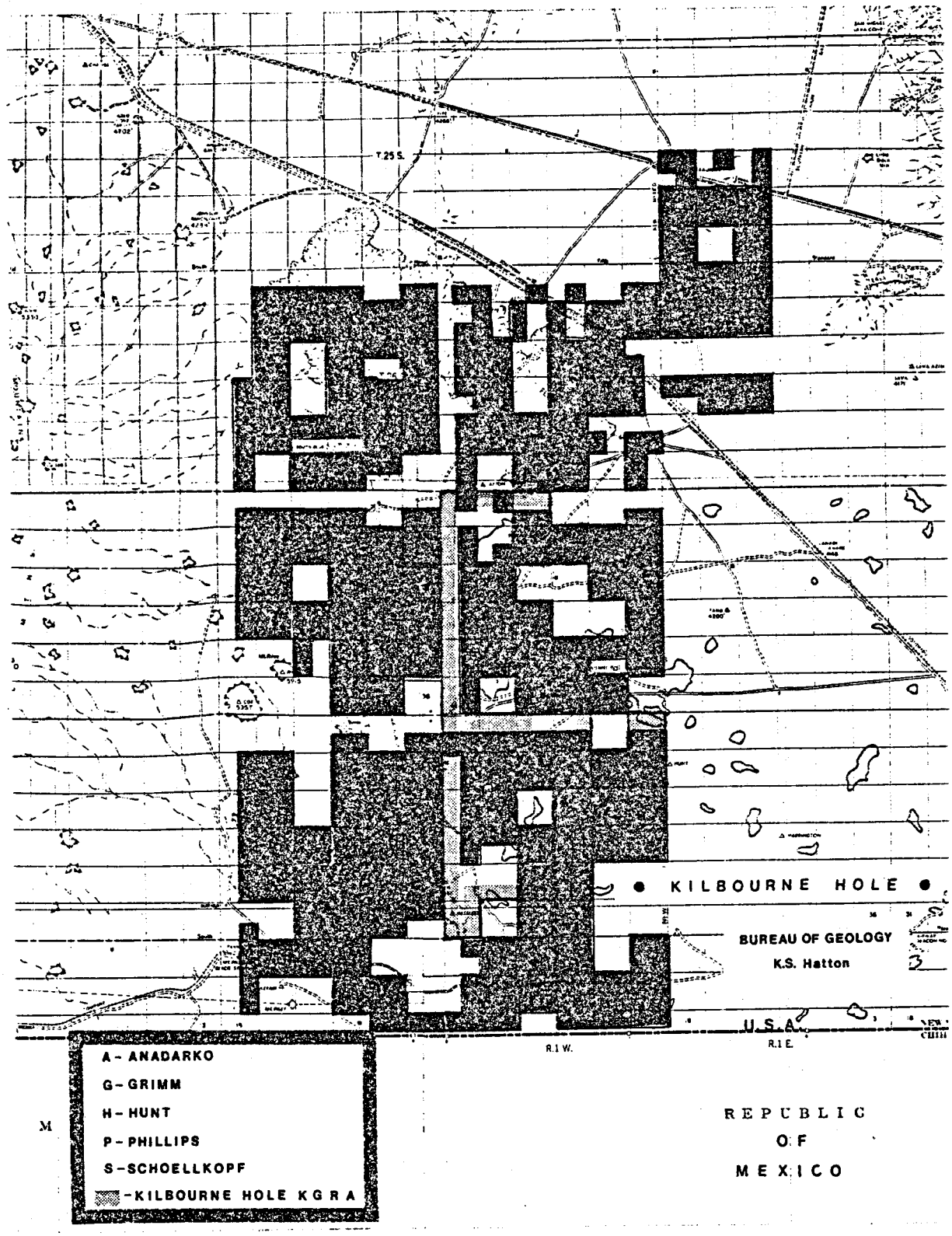



Figure 9. Kilbourne Hole Geothermal Resource Area

Site Location: R.1W., T.27S., and T.28S.

Latitude: 31° 57'N Longitude: 106° 58'S

County: Dona Ana

Land Ownership: Federal

Land Use: Range

Description of KGRA: 25,133 acres, in R. W, T27 and 28S.

Leasing Status:

Within KGRA: 18,476.45 acres - Anadarko
2,557 acres Phillips

Adjacent to KGRA: 57,849 acres Hunt
6,264 acres Grimm
9,636 acres Schoellkopf

Filed on, but not yet issued:

7,010 acres Geothermal Power Corp.
2,560 acres Cecil J. Folmar
2,560 acres G.W. Seltzer, M.D.

## 30.3 Development Status and Activity

Anadarko Productions, who seems to be out front in exploration progress in this area, made a ground gravity survey in 1976 in T.27S., R.1W. and in T.28S., R.1W. and conducted a ground electric survey in 1977. Approval has been given by USGS to Anadarko to drill 16 temperature gradient holes 500 feet deep and four holes 2500 feet deep. The Anadarko operation will make the first time the deeper geologic exploration has been conducted here.

Hunt Energy Corporation has conducted a reconnaissance electric resistivity survey south of Kilbourne Hole in the Potrillo Mountains in T.25S., R.3&4W., T.26-29S., R.1-4W, which is midway between Columbus and Anthony, New Mexico.

Hunt has drilled 54 temperature gradient holes in T.25S., R.3&4W., T.26-29S., R.1-4W., also in the Potrillo Mountains. To Hunt, the Kilbourne Hole area looks interesting on the basis of their findings.

Phillips Petroleum has drilled five or six gradient holes. Findings have been disappointing.

## 30.4 Severe Development Problems

This area is very sparsely populated and it is not very assessable. Consequently, space heating and process heating may not be economical in the immediate area, but could be feasible in the Rio Grande Valley with transported geothermal fluids.

## 30.5 Development Scenario

At this time, no reserves have been proven, thus the development plan is highly speculative.

# Table 13

POSTULATED SITE DEVELOPMENT SCHEDULE
KILBOURNE HOLE

WBS 7004

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Developer | Conducts casual reconnaissance exploration | — | — | | | | | | | | | | | |
| BLM, State | Leases Land | — | | | | | | | | | | | | |
| USGS | Makes Environment Assessment | — | | | | | | | | | | | | |
| USGS, State | Approves Plan of Operation and issues permit to explore | | — | | | | | | | | | | | |
| Developer | Conducts geophsical work and drills T.G. holes | | — | | | | | | | | | | | |
| USGS | Makes EA for drilling deep exploratory wells | | | — | | | | | | | | | | |
| USGS, State | Gives permission to drill | | | — | | | | | | | | | | |
| Developer | Drills deep exploratory well | | | — | — | | | | | | | | | |
| Developer | Conducts Feasibility Study | | | | — | | | | | | | | | |
| Developer | Water rights application with State Engineer | | | | — | | | | | | | | | |
| USGS | Makes EA for development | | | | — | — | | | | | | | | |
| | Gives permission to develop | | | | | — | | | | | | | | |
| Developer | Drills production wells and runs tests | | | | | — | — | — | | | | | | |
| PSC | Certifies plant and site | | | | | | | — | | | | | | |
| | Issue permits | | | | | | | — | | | | | | |
| USGS | Approves plan of operation for production | | | | | | | — | | | | | | |
| Utility | Obtains R.O.W. for Power Line | | | | | | | — | | | | | | |

POSTULATED SITE DEVELOPMENT SCHEDULE
KILBOURNE HOLE

WBS 7004

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Utility | Plant Construction | | | | | | | | ——— | | | | | |
| Utility | Puts power on line | | | | | | | | | 10 MW ▲ | 25MW ▲ | 50 MW ▲ | ——— | |

LOS ALTURAS WBS 7017

General Description

The Los Alturas area is southeast of Las Cruces on the east edge of the Rio Grande Valley.

This area has a thermal anomaly that underlies a subdivision of the same name and adjacent state university property to the north. When the subdivision started up in 1967, it was beyond the reach of city water and so, the homeowners drilled wells for their water supply. The water from these wells ranged from midely warm ($77^{o}F$) to hot ($113^{o}F$).

In 1948, an oil test well was drilled nearby and it encountered steam and hot water. This same well will be reentered for temperature measurement as part of the NMSU feasibility study to assess the resource potential for meeting heating, cooling, and electrical power needs of the NMSU campus.

Information is being gathered on the thickness and bounds of the aquifer in order to arrive at an estimate of the amount of energy available. Water temperature, however, and the depth at which that temperature might be found can only be proven by drilling.

In conclusion, the Los Alturas and the adjacent Las Cruces area appears highly favorable from the geological point of view and merits continued study.

30.2 Resource Characteristics - LOS ALTURAS

Surface Fluid Temperature: $115^{o}F$ or $46^{o}C$

Subsurface Fluid Temperature: $120^{o}C$

Total Dissolved Solids: Range from 1093 to 1983 ppm

Estimated Energy Potential: $141.75 \times 10^{15}$ cal. (stored heat)

Type of Overlying Rock: Sand and gravel overlying Mississippian sediments

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 2.25 cubic km

Site Location: Los Alturas Subdivision (adjacent to I-25) and university land including golf course.

Latitude: $32^{o}16'$ Longitude: $106^{o}42'$

County: Dona Ana

Land Ownership: University property of N.M.S.U. and private property of Los Alturas Development Company

Land Use: University: none except golf course; Los Alturas Estates is a residential subdivision.

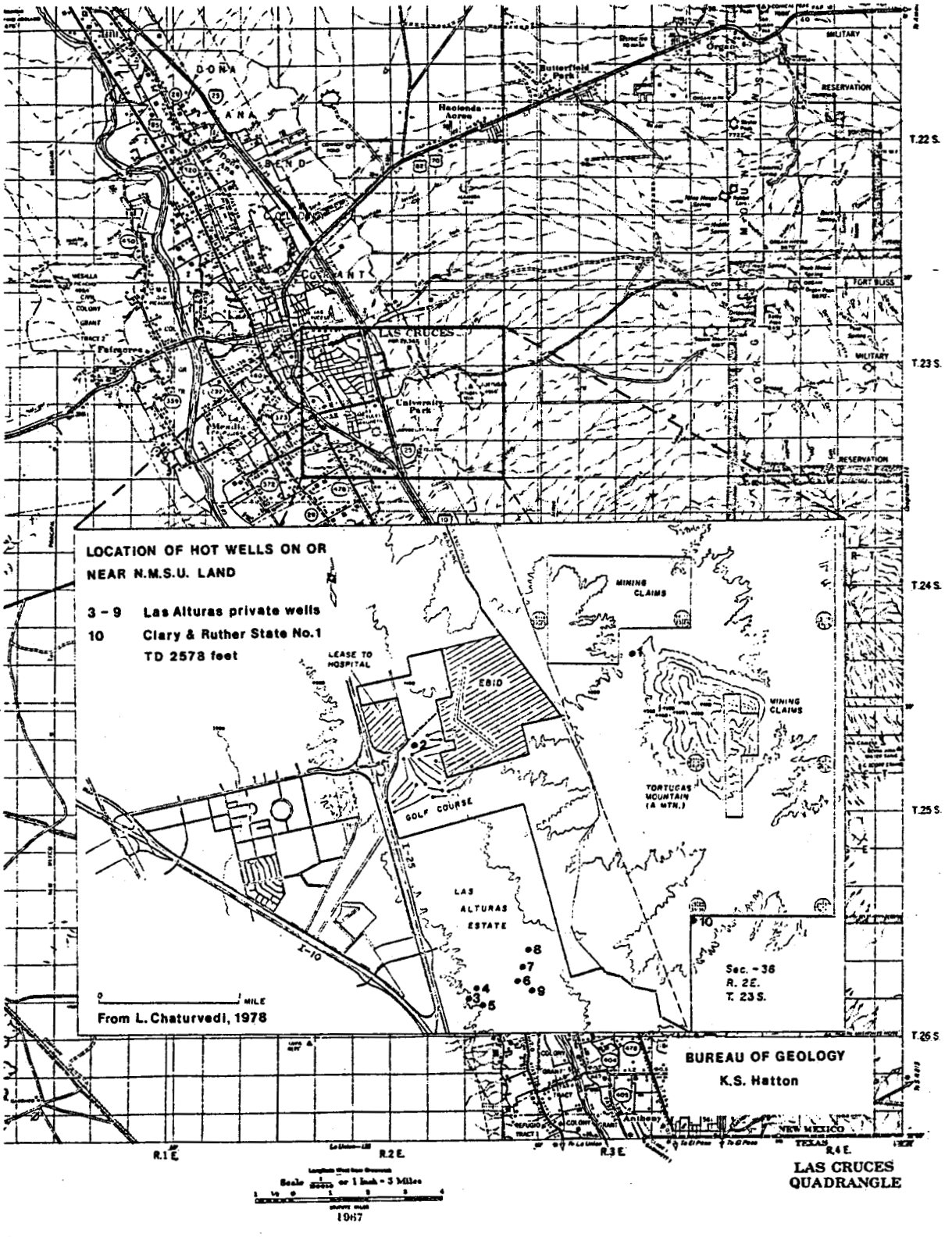



Figure 10. Las Alturas Geothermal Resource Area

Description of KGRA: None

Leasing Status: None

## 30.3 Development Status and Activity

The development in this area is wholly conducted by the state university. A good deal of geophysical exploration has been conducted by some of the NMSU geothermal workers. This includes shallow temperature gradient holes and electrical resistivity tests. The feasibility study for campus space-heating accelerated this spring and verification drilling will begin soon.

## 30.4 Severe Development Problems

None anticipated.

## 30.5 Development Scenario

This area is a candidate for the state geothermal space heating demonstration program which provides a state fund of $200,000.

OJO CALIENTE WBS 7009

## General Description

The Ojo Caliente area is located in the Ojo Caliente Valley about 18 miles directly north of Espanola. It consists of moderately rugged country that supports some ranching. The communities consist of La Madera and Ojo Caliente with a combined population of about 500.

Recently, the Bureau of Land Management has selected this area for study for geothermal leasing because industry has shown interest in the area by filing at least three geothermal lease applications. This area is known as the "Ojo Caliente Geothermal Leasing Area." The proposed action is to offer for geothermal leasing about 137,940 acres of public land in Rio Arriba and Taos Counties, New Mexico. The decision based on the final environmental assessment record (to be released in late August) will be made prior to 1979.

There are five hot springs which are owned and operated by Ojo Caliente Mineral Springs Company as a resort spa. Their temperatures range from $90^{o}F$ to $113^{o}F$. A water well located just a quarter mile north reported $132^{o}F$ at 87 feet depth.

The most reasonable uses of the geothermal resources in the area would be for space heating, greenhouses, or lumber processing plants. If potential occurs for power generation, either Plains Electric Coop or PNM would probably be involved.

30.2 Resource Characteristics - OJO CALIENTE

Surface Fluid Temperature: $113^{o}F$ $45^{o}C$

Subsurface Fluid Temperature: $122^{o}C$ - $161^{o}C$

Total Dissolved Solids:

Estimated Energy Potential:

Type of Overlying Rock: Fractured metarhyolite crisscrossed by pegmtite dikes

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: 2.25 cubic km

Site Location: T.24N., R.8E, Section 24

Latitude: $36.31^{o}$ Longitude: $106.05^{o}$

County: Taos

Land Ownership: Primarily private and commercial including: Ojo Caliente Mineral Spring Company

Land Use: Grazing, residential, resort spa

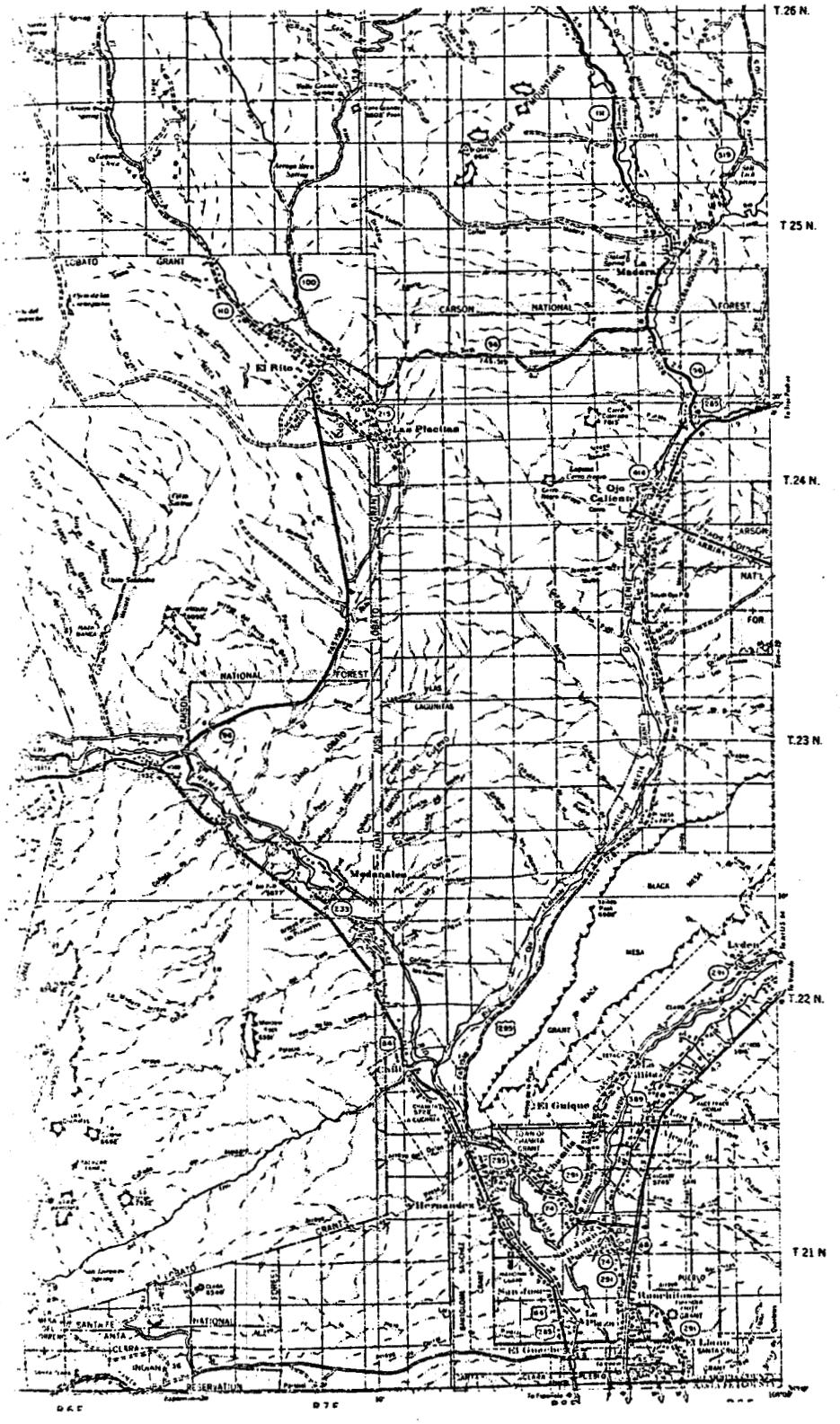



Figure 11. Ojo Caliente Geothermal Resource Area

Description of KGRA: None

Leasing Status: State GTR 153 T.24N., R.8E., Section 2, A.J. Antweil, 160 acres

Federal application by A.J. Antweil for 7,000 acres surrounding the above state parcel is still pending.

## 30.3 Development Status and Activity

No leases have been issued, with the exception of one state lease held by A. J. Antweil, and no drilling or exploration has been conducted. Hot Springs are actively used at the resort spa; however, the resort buildings are not geothermally heated, although they could be. The Bureau of Land Management recently has prepared an Environment Assessment Record in consideration of offering public lands for geothermal leasing.

## 30.4 Severe Development Problems

A.J. Antweil & Company is awaiting action on the federal application for three leases of 7,000 acres in the Ojo Caliente area. After three years, inactivity of the Bureau of Land Management has forced Antweil & Company to postpone preliminary exploration plans. It may be some time (possibly Fall of 1978) before BLM makes a decision based on its recently published EAR. This area is environmentally sensitive in a slight to moderate way.

## 30.5 Development Scenario

This was developed based on the assumption of federal approval for leasing and exploration.

## RADIUM SPRINGS WBS 7008

### General Description

The Radium Springs area is located about 12 miles north of Las Cruces in the Rio Grande Valley. The combined population of the local communities of Radium Springs, Leasburg and Hill is about 1,000. It is to the east of Interstate 25 and includes San Diego Mountain six miles to the north. San Diego Mountains has one of the highest heat flows in the state, indicating a possible shallow hydrothermal system beneath the ground surface.

The Radium Springs Hotel resort has hot springs of temperatures of about 140°F, which is used for bathing and space-heating.

The land in the valley is private but, land outside the valley is state and federal owned. The Radium Springs KGRA, which is centered on the Leasburg Dam, has 9,812 acres.

The potential users of geothermal energy are the area residents who are dependent almost entirely on the extensive agriculture of pecan, onions, chili peppers, and cotton.

Geothermal crop-drying plants could prove very useful here since the energy needs are hampered by limitations on natural gas. El Paso Electric Company conceivably could be the potential utility for geothermal power generation since it has 115 kv line on location.

Chevron is currently drilling temperature gradient test holes in the area.

30.2 Resource Characteristics - RADIUM SPRINGS

Surface Fluid Temperature: 30° - 85°C

Subsurface Fluid Temperature: 130°C - 198°C

Total Dissolved Solids: 3700 ppm

Estimated Energy Potential: Indicated - 41 MW thermal

Type of Overlying Rock: Rhyolite

Estimated Depth from Top of Reservoir: Unknown

Estimated Size of Reservoir: 2.25 $km^3$ (assumed)

Site Location: T.21S., R.1W., Section 10

Latitude: 32°30'N Longitude: 107°58'W

County: Dona Ana

Land Ownership: State & Federal - some private

Land Use:

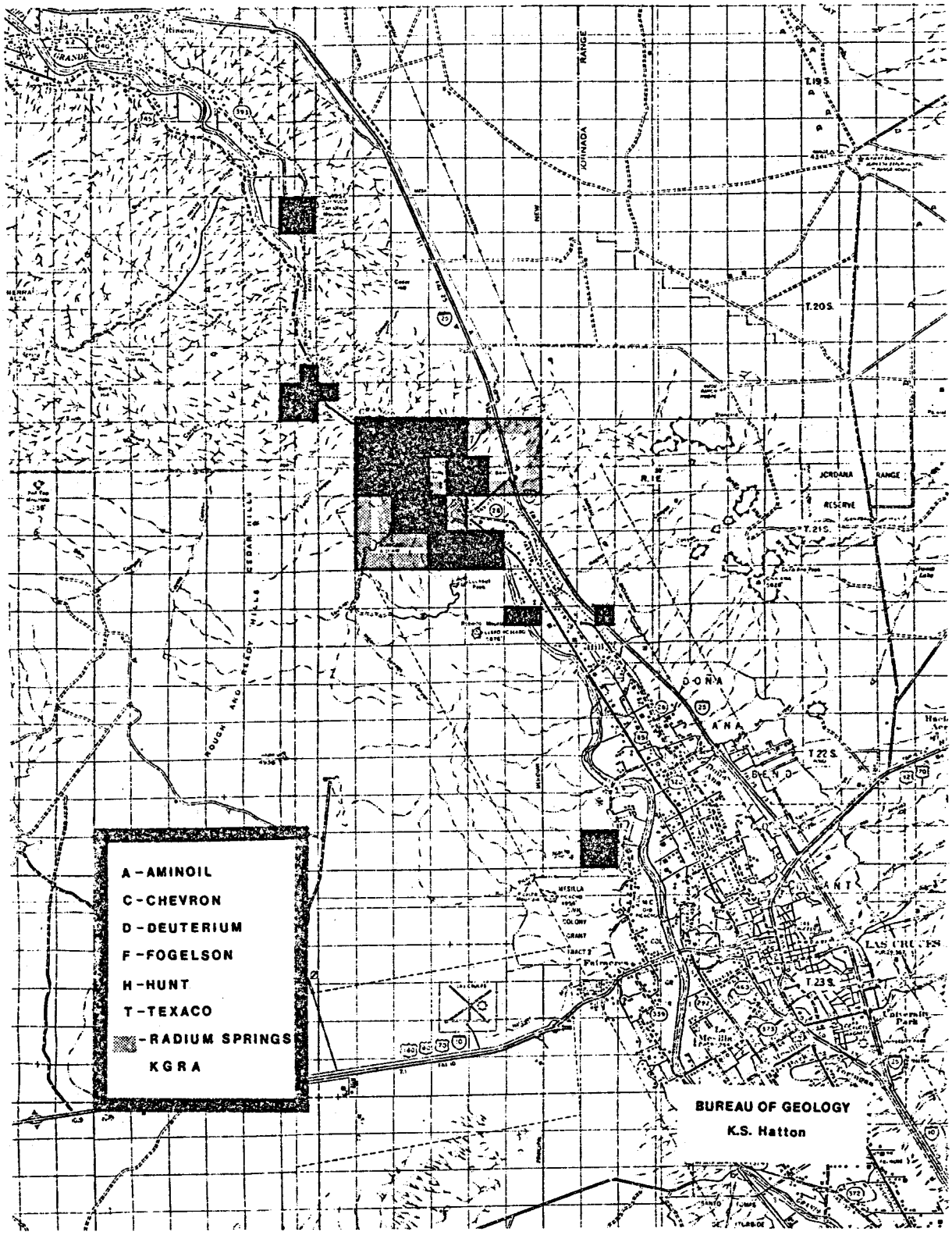



Figure 12. Radio Springs Geothermal Resource Area

Description of KGRA: 16 sections in upper part of T.21S., R.1W., Totaling 9,812 acres

Leasing Status: Federal leases in the KGRA, obtained by competitive bid held by:

| | |
|---|---|
| Chevron | 1,227 acres |
| Texaco | 1,158 acres |
| Aminoil | 12,354 acres |

Hunt filed for lease in 1975 on about 15,000 acres in R.20 and 21S., R.W. The BLM has yet to act on the application, although the EAR has been completed.

## 30.3 Development Status and Activity

Hunt has completed an electrical resistivity survey and has drilled some temperature gradient holes in the areas. The results are of interest, so Hunt would like to drill some deeper holes in order to verify the trends seen in the shallow holes, but first leases must be obtained.

Chevron has made Magneto - Telluric surveys, a gravity survey and has drilled two temperature gradient holes.

## 30.4 Severe Development Problems

Hunt filed on approximately 15,000 acres in T.20 and 21S., R.1W., in 1975; the leases have not yet been granted, although the BLM has completed the Environmental Assessment Report on the area. Until the leases are obtained, little further exploration is warranted.

# Table 14

POSTULATED SITE DEVELOPMENT SCHEDULE
RADIUM SPRINGS

WOS 7008

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Developer | Conducts casual reconnaissance exploration | ——— | ——— | | | | | | | | | | | |
| BLM, State | Leases Land | ——— | | | | | | | | | | | | |
| USGS | Makes Environment Assessment | ——— | | | | | | | | | | | | |
| USGS, State | Approves Plan of Operation and issues permit to explore | | ——— | | | | | | | | | | | |
| Developer | Conducts geophsical work and drills T.G. holes | | ——— | ——— | | | | | | | | | | |
| USGS | Makes EA for drilling deep exploratory wells | | | ——— | | | | | | | | | | |
| USGS, State | Gives permission to drill | | | — | | | | | | | | | | |
| Developer | Drills deep exploratory well | | | ——— | ——— | | | | | | | | | |
| Developer | Conducts Feasibility Study | | | ——— | | | | | | | | | | |
| Developer | Water rights application with State Engineer | | | | ——— | | | | | | | | | |
| USGS | Makes EA for development | | | | ——— | ——— | | | | | | | | |
| | Gives permission to develop | | | | | — | | | | | | | | |
| Developer | Drills development wells and runs production tests | | | | | ——— | ——— | ——— | | | | | | |
| PSC | Certifies plant and site | | | | | | ——— | ——— | | | | | | |
| | Issue permits | | | | | | | — | | | | | | |
| USGS | Approves plan of operation for production | | | | | | | ——— | | | | | | |

POSTULATED SITE DEVELOPMENT SCHEDULE
RADIUM SPRINGS

WBS 7008

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Utility | Obtains R.O.W. for Powerline | | | | | | | — | | | | | | |
| Utility | Plant Construction | | | | | | | | — | — | | | | |
| Utility | Puts power on line | | | | | | | | | — | — | — | — | |

SAN YSIDRO WBS 7037

## General Description

The San Ysidro geothermal area is located near the Village of San Ysidro at the confluence of the Rio Salado and the Jemez River. Discovery of economic sources of geothermal energy in this part of New Mexico would benefit the communities of Jemez Pueblo, Zia Pueblo, and San Ysidro which have a combined population of about 800.

The populace is heavily dependent on propane gas and electricity for their energy needs. A 115 kv power line by Plains Electric Coop runs through the area.

The United States Geological Survey has designated 5120 acres in the area as a Known Geothermal Resource Area. This is bordered on the north by the Jemez Indian Reservation and on the east and west by the Zia Indian Reservation.

There are several sources of hot wells, springs and warm springs located in the area. Most of these are located on Indian land. Although these springs have been used by the Indians for bathing throughout the years, there is no commercial development and none is planned so far.

The heat capacity of the reservoir is believed to be 23 MW thermal for 30 years and could be sufficient to heat 4550 dwellings for the same time.

Much of the area in which leases have been filed for is being withheld as a scenic area, pending outcome of an appeal. Leasing and exploration, however, is inactive. Leasing and exploration on Indian lands have to be arranged with each Pueblo individually.

30.2 Resource Characertistics - SAN YSIDRO

Surface Fluid Temperature: $50^{o}C$

Subsurface Fluid Temperature: $80^{o}C$

Total Dissolved Solids: 10,000 - 12,000 ppm

Estimated Energy Potential: 23 thermal MW for 30 years
Heat for 4550 dwellings for 30 years

Type of Overlying Rock: Sandstone and shale

Estimated Depth from Top of Reservoir: Unknown

Estimated Size of Reservoir: 2.25 $km^3$ (assumed)

Site Location: T.15., R.1E./confluence of Rio Salado & Jemez River

Latitude: $35^{o}30'N$ Longitude: $106^{o}40$-5-'N

County: Sandoval

Land Ownership: Mostly Federal and Indian (Zia and Jemez)

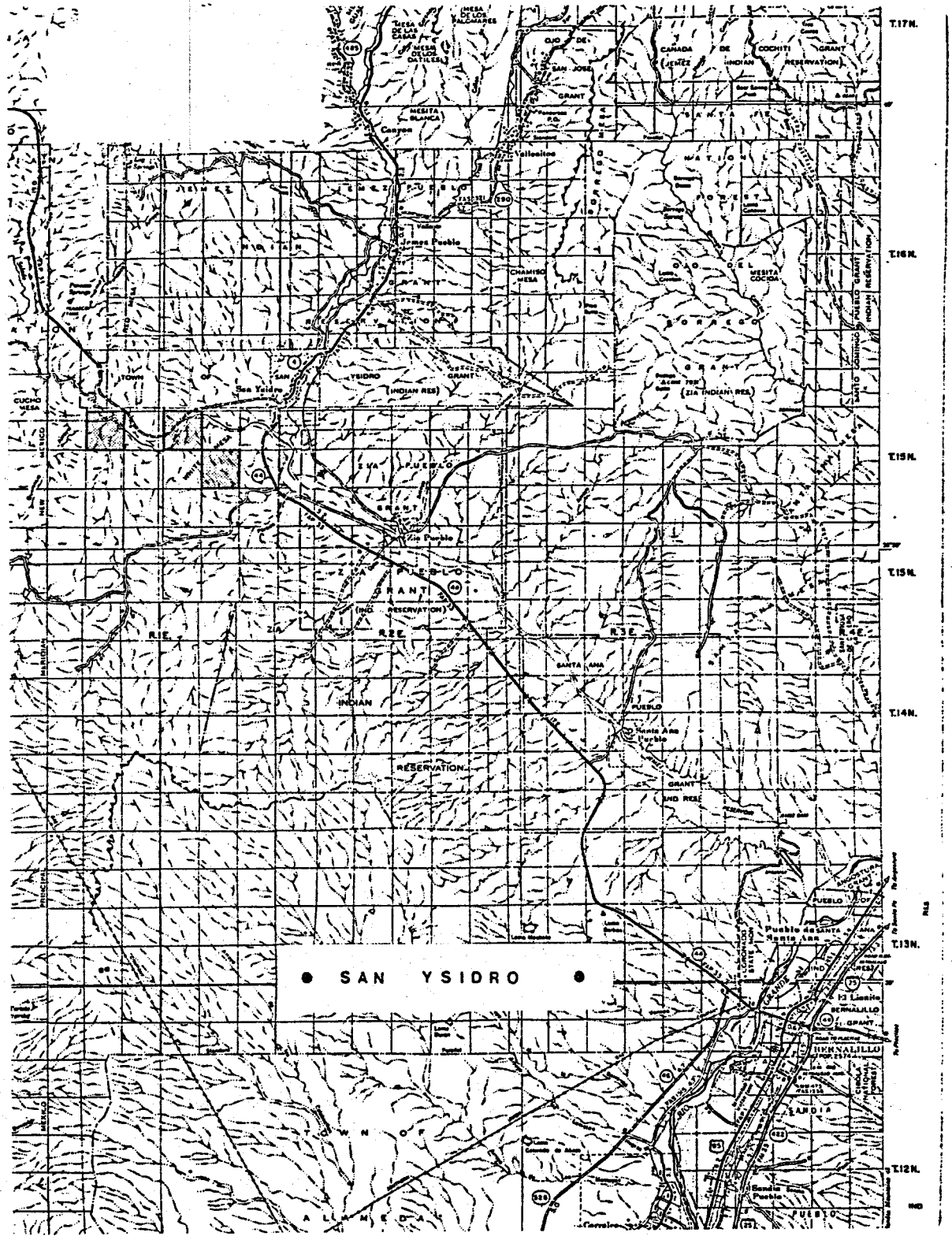



Figure 13. San Ysidro Geothermal Resource Area

Land Use: Hot Springs bathing area

Description of KGRA: Three sections in T.15N., R.1E. - 1915 acres

Leasing Status: Much of the land, about 10,000 acres, which has been filed on has been withheld from leasing because it is considered a scenic area of special value. Anshutz and Hunt are appealing this decision.

Cherokee and Pittsburg Coal and Mining Company holds 1920 acres in the area.

Thermal Springs and wells six miles to the north are on Inidan land. Leasing and exploration on Indian lands must be arranged with each Pueblo individually.

Occidental Geothermal has filed for 5073 acres in May, 1978.

## 30.3 Development Status and Activity

The KGRA consists of three sections in T.15N., R.1E., but much of the not spring activity is about six miles to the north in T.16N., R.1E. and 1 W.

Two oil tests were drilled in this northern area in 1926 on the Rio Salado Anticline, which lies within the Zia Indian Reservation. One of the wells, the Kaseman No. 2, flowed warm water and has been used as a source of hot water for the Warm Springs Bathhouse, located nearby.

No requests to explore in the San Ysidro area have been made. Leases on Indian land are available only through a sale, but there are no plans for such a sale in the near future.

## 30.4 Serious Development Problems

Obtaining leases on Indian land, which includes most of the area, will be a slow process that might hold up development for several years.

Some lease applications on federal land have been held up because the hot springs are considered to be a unique scenic area.

## 30.5 Development Schedule

Since little or no exploration has been done in the area and leases on federal and Indian land will be difficult to obtain, no development is predicted for the next five years, at least.

## SOCORRO WBS 7005

### General Description

The Socorro geothermal area is located in the Rio Grande Valley about 75 miles south of Albuquerque. Discovery of economic sources of geothermal energy in this part of New Mexico would benefit the communities of Socorro San Antonio, Luis Lopez, Florida, Escondida, Polvadera, Lemitar, San Acacia, and Alamillo which have a combined population of about 8,000. A shortage of natural gas in Socorro, by far the largest community in the area, has lead to restrictions on its use, particularly in new residences. Thus the development and use of goethermal energy would have an important effect on the economic development of the region.

The United States Geological Survey has designed 89,715 acres surrounding Socorro as a Known Geothermal Resource Area (KGRA). Most of the scientific data indicating this region has promise as a geothermal resource has been obtained over the past decade by investigators at New Mexico Tech which is located in Socorro. With the possible exception of the KGRA in the Jemez Mountains near Los Alamos, the Socorro KGRA is the most thoroughly investigated geothermal area in the state.

There are three springs in the area that discharge warm waters along a north-trending fault which separates the Socorro Peaks from the Rio Grande Valley. Their temperatures range from 66°F to 112°F.

Perhaps because of the extensive geological and geophysical studies near Socorro, the geothermal industry has shown considerable interest in the area. To date, 6,694 acres of state land and 11,657 acres of federal land have been leased. Some of the major companies that hold leases and/or have active exploration programs in the area are Sunoco, Aminoil, Gulf and Chevron. One company, Sunoco, has started a program of moderately deep drilling, 500 feet to 2000 feet, to test the geothermal potential of the region.

Engineers and geoscientists at New Mexico Tech are investigating the possibility of developing low-grade geothermal energy for campus heating. Drilling of test holes is planned within a year after investigation of some of the possible environmental problems associated with the development of geothermal energy near the campus community.

Source: Al Sanford, New Mexico Institute of Mining Technology

### 30.2 Resource Characteristics - SOCORRO

Surface Fluid Temperature: 34°C

Subsurface Fluid Temperature: 72°C

Total Dissolved Solids: Approximately 100 ppm

Estimated Energy Potential: Indicated: 7 MW thermal for 30 years
Inferred : 15 MW thermal for 30 years

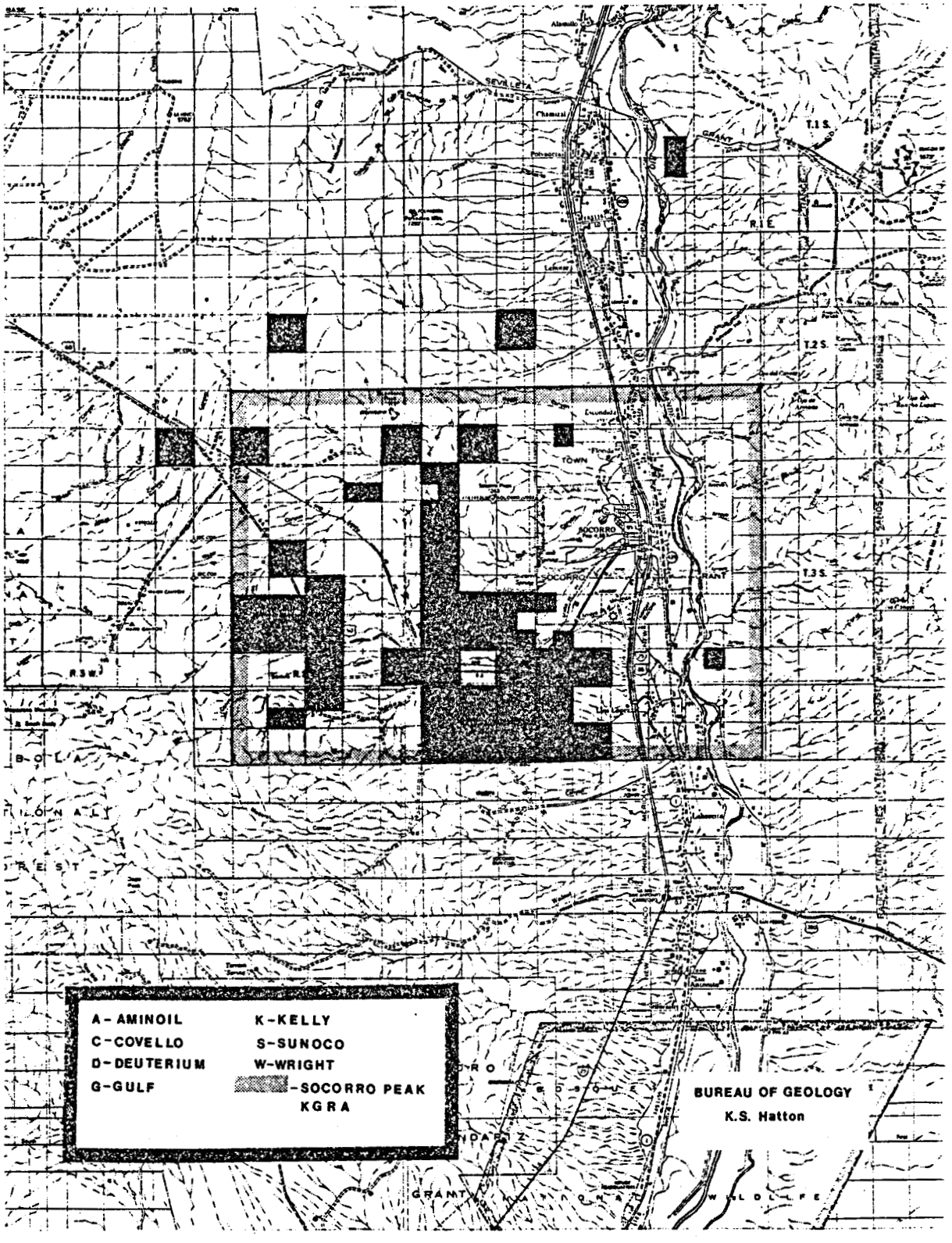



Figure 14. Socorro Geothermal Resource Area

Type of Overlying Rock: Volcanic breccia

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir: Assumed 2.25 $km^3$

Site Location: R1, 2, 3W and R1E and T1, 2, 3, and 4S

Latitude: $34^{o}2'$ Longitude: $106^{o}56'$

County: Socorro

Land Ownership: 50% - Spanish Land Grant of Socorro
30% - State
20% - Federal

Land Use: Cattle Grazing and Municipality Zoned

Description of KGRA: 89,715 acres in R1, 2W and R1E and T2, 3, and 4S

Leasing Status:

STATE

| | |
|---|---|
| Gulf Oil | 1,820 acres |
| John Kelly | 2,720 acres |
| J.W. Covello | 160 acres |
| Deuterium Geo. | 480 acres |

FEDERAL

| | |
|---|---|
| Sunoco Energy Development Co. | 2,565 acres |
| Wright, Hoover H. | 1,920 acres |
| Wright, Hoover H. | 1,489 acres |
| Wright, Hoover H. | 1,914 acres |
| Aminoil USA, Inc. | 2,390 acres |
| Aminoil USA, Inc. | 662 acres |
| Aminoil USA, Inc. | 2,047 acres |
| Aminoil USA, Inc. | 1,920 acres |
| Sunoco Energy Development Co. | 2,073 acres |

## 30.3 Development Status and Activity

A considerable number (7) of geological and geophysical studies have been conducted near Socorro by the New Mexico Tech academicians. In light of this, geothermal heating of the NMIMT campus is being considered seriously. Although no actual drilling has been made, a slim-hole drilling and analysis is anticipated in early 1979. Lease state lands have been extensively explored and federal lands were just recently leased. Nearly all the interested companies have completed preliminary geophysical exploration studies. Sunoco is drilling five temperature gradient holes, 500 feet to 1500 feet during the summer of 1978 and has completed 23 others. Phillips completed 8 T.G.

30.4 Severe Development Problems

Many of New Mexico Tech staff members are opposed to geothermal development of any kind due to "environmental problems" and will not accept any trade-offs with their environmental quality.

## Table 15

POSTULATED SITE DEVELOPMENT SCHEDULE
SOCORRO

WBS 7055

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Developer | Conducts casual reconnaissance exploration | | — | | | | | | | | | | | |
| BLM, State | Leases Land | | — | | | | | | | | | | | |
| USGS | Makes Environment Assessment | | — | | | | | | | | | | | |
| USGS, State | Approves Plan of Operation and issues permit to explore | | — | | | | | | | | | | | |
| Developer | Conducts geophsical work and drills T.C. holes | | — | | | | | | | | | | | |
| USGS | Makes EA for drilling deep exploratory wells | | | — | | | | | | | | | | |
| USGS, State | Gives permission to drill | | | • | | | | | | | | | | |
| Developer | Drills deep exploratory well | | | — | — | | | | | | | | | |
| Developer | Conducts Feasibility Study | | | — | — | — | | | | | | | | |
| Developer | Water rights application with State Engineer | | | | — | | | | | | | | | |
| USGS | Makes EA for development | | | | — | — | | | | | | | | |
| | Gives permission to develop | | | | | • | | | | | | | | |
| Developer | Drills development wells and runs production tests | | | | | — | — | — | | | | | | |
| USGS | Approves plan of operation | | | | | | — | | | | | | | |
| Developer/User | District Heating System Installed | | | | | | | — | | | | | | |
| Developer/User | Space Heating on line | | | | | | | • | | | | | | |

TRUTH OR CONSEQUENCES WBS 7024

General Description

The Truth or Consequences thermal area occurs along the west side of the Rio Grande River between the northwest-trending Mudsprings Mountain and the Sierra Caballos. The thermal waters apparently occur entirely with T or C. This town has the largest collection of hot springs and wells in the state which resulted in extensive development of spas, mineral baths, and resort hotels.

The communities of T or C and Williamsburg have a combined population of about 6,100 and are entirely dependent on natural gas for heating purposes.

Very little study has been conducted of the geothermal potential in this area. Geothermal leasing of state and federal lands is insignificant. Presently, the general populace does not seem to be receptive towards new potential use and development such as space-heating.

30.2 Resource Characteristics - TRUTH OR CONSEQUENCES

Surface Fluid Temperature: $36^{o}C$ - $46^{o}C$

Subsurface Fluid Temperature: $100^{o}C$

Total Dissolved Solids: 2500 ppm

Estimated Energy Potential: 114.75 X 1015 calories

Type of Overlying Rock: Alluvium and valley fill underlain by Paleozoic Magdalena limestone

Estimated Depth from Top of Reservoir:

Estimated Size of Reservoir:

Site Location: T13S, R4W including city limits of T or C

Latitude: $33^{o}09'$ Longitude: $107^{o}15'$

County: Sierra

Land Ownership: Private residential and commercial property

Land Use: Residential and commercial use

Description of KGRA: None

Leasing Status:

STATE GTR 155 T13S R4W Deuterium Geothermal (this firm is now defunct)
Sec. 16

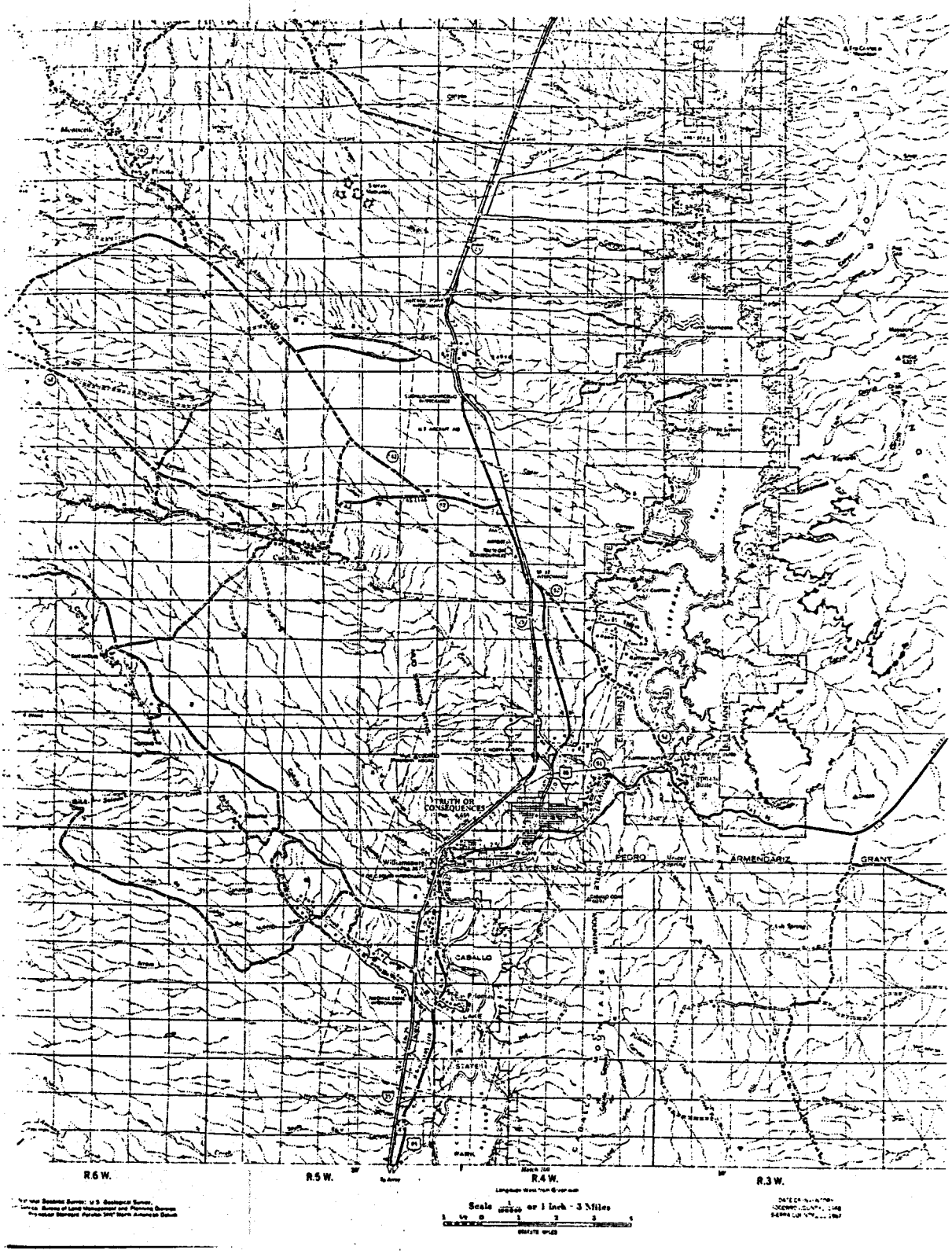



Figure 15. Truth or Consequences Geothermal Resource Area

## 30.3 Development Status and Activity

Bill Chowning, owner of Yucca Lodge in T or C, has rigged up his own space heating system, using refrigeration coils. Water is taken from the hot pool at approximately 108°F, pumped at about 10 psi through the system. It has a fan behind to help distribute heat. Heat is very even and comfortable. Pumping rate is approximately 1½-3 gpm/unit.

There are 10 to 12 thermal wells within a 120 acre hot spot located within town, which could be used for space heating. There have been no corrosion problems with the water in piping. Water contains about 2700 ppm of dissolved solids.

## 30.4 Severe Development Problems

The townspeople seem to lack interest in developing and using the resource. Evidently they are satisfied with the present heating system with natural gas.

## 30.5 Development Scenario

Potential for geothermal space heating may be adequate for the town. A recent thesis (UNM) gives an understanding of the geology that will aid in locating a drilling site for a hold that will evaluate porosity, heat flow and water volume. The resulting information will help in deciding on the next step in development. Perhaps a test can be started early next year (1979).

## VALLES CALDERA WBS 7001

### General Description

The Valles Caldera is a large extinct volcanic structure that comprises the central portion of the Jemez Mountains in North Central New Mexico. It is about 14 miles in diameter. The communities of Los Alamos, White Rock, and Jemez Springs are located on the flanks of this caldera. These communities have a combined population of about 20,000. With the exception of Donigan's Baca Ranch, the caldera area is nearly uninhabited.

Numerous hot springs occur in the area and the United States Geological Survey has designated this area as the Baca Location No. 1 KGRA. This geothermal resource has a large heat capacity in both hot, dry rock and hydrothermal systems.

The Los Alamos Scientific Laboratory has created much interest with their hot dry rock experimental facility at Fenton Lake which is a few miles southwest of the caldera rim. The Federal Government has asked LASL to investigate the possibilities of geothermally heating the lab building in Los Alamos.

The most significant industrial activity to date is that being conducted by Union Oil Company. This company has developed wells in the Redondo Creek area which has rugged topography and is relatively secluded. The hills surrounding the valley are heavily timbered and have an elevation of about 9000 feet.

The field is the one geothermal energy source in the state that is certain to become a producer of energy. An electric generating plant is to be build there, designed to produce about 50,000 kilowatts. This energy will be sent out by wire to the east, to tie to the network in the vicinity which supplies electricity to cities like Santa Fe and Albuquerque. Plans are to have the plant on line in 1982.

30.2 Resource Characteristics - VALLES CALDERA

Surface Fluid Temperature: 88°F in Spring in Sulfur Creek nearby to the West

Subsurface Fluid Temperature: 260-315°C

Total Dissolved Solids: 7000 ppm

Estimated Energy Potential: Identified: 400 MW for 30 years
Inferred : 1,942 MW for 30 years

Type of Overlying Rock: Tuff, Rhyolite

Estimated Depth from Top of Reservoir: 1,000 feet (+) below surface

Estimated Size of Reservoir: 130 $km^3$ - one mile wide and 1 3/4 mile long (60 cubic miles)

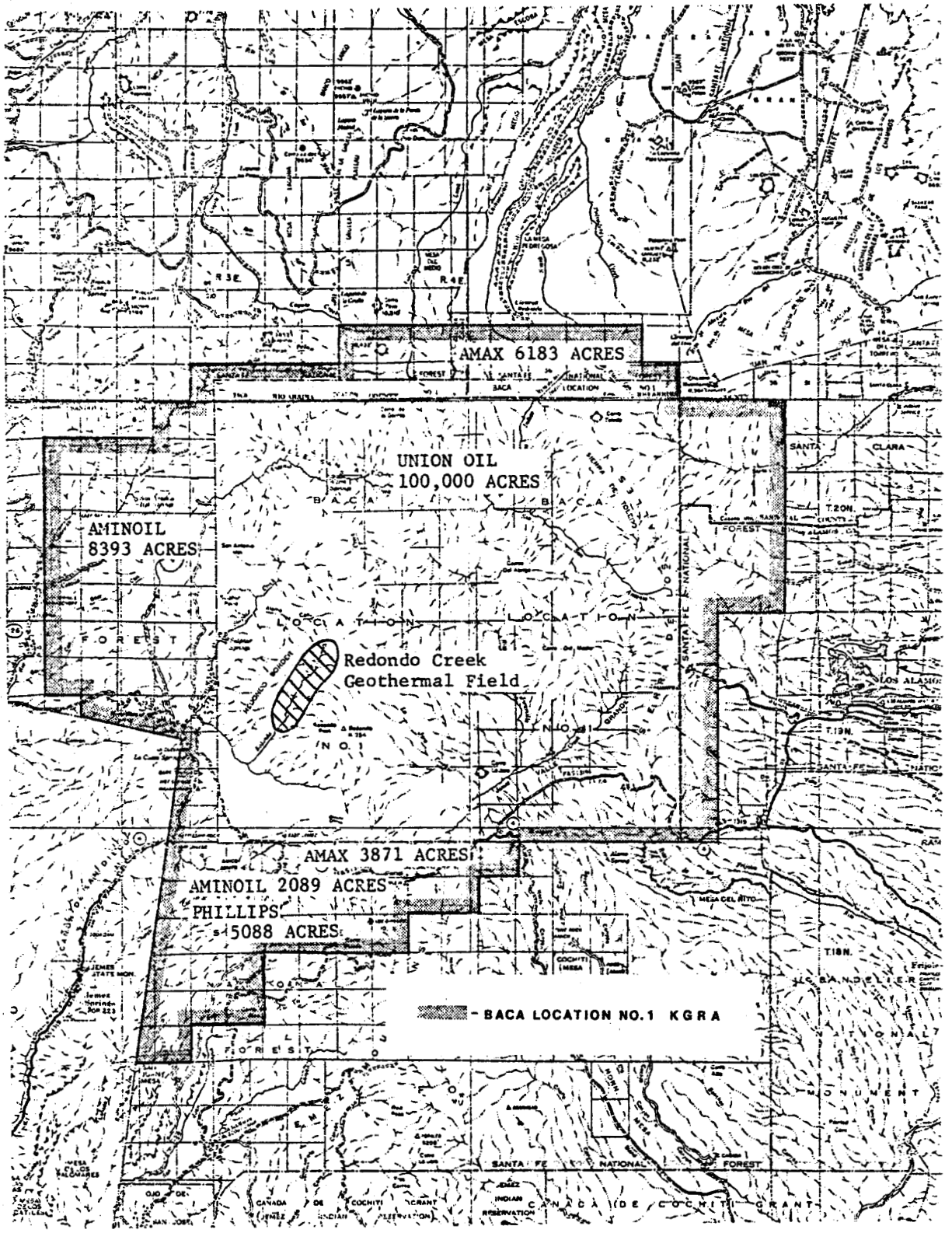



Figure 16. Valles Caldera Geothermal Resource Area

Site Location: T.19N., R.2E. Redondo Creek

Latitude: $35^{o}53'$N. Longitude: $106^{o}35'$W.

County: Sandoval

Land Ownership: Private - Federal

Land Use: Ranching and timber

Description of KGRA: T. 18, 19, 20, 21, N., R. 2, 3, 4, 5, 6, E.
Totaling 168,761 acres

Leasing Status: Approximately four townships of the KGRA lie within the Baca Location #1.

Approximately three townships lie on the flanks of this privately owned area.

NOTE: The Redondo steam field, developed and operated by Union Oil Company of California, is all located within the Baca Location No. 1, privately owned land. On the flanks of the fee land leases awarded in competitive federal sales are held by:

| | |
|---|---|
| Amax | 10,054 acres |
| Phillips | 5,090 acres |
| Aminoil | 10,483 acres |

These leases were issued in late 1977 and early 1978.

## 30.3 Development Status and Activity

This geothermal field has the greatest proven reserves of any in the state. It has been developed over a period of several years by the Union Oil Company and today has ample proven reserves to run the 50 MW plant proposed to be on line by 1982.

Union Oil and Public Service Company of New Mexico have formed a partnership with a $50 million grant from DOE to build a demonstration power plant using the steam - hot water resource to produce electric power. Union Oil and PNM will contribute $25 million each into the project.

Union Oil Company has much experience in the commercial development of California's Geysers Geothermal Field. In New Mexico, it is an operator for a group including itself, Dunigan Enterprises, Inc. and Baca Land and Cattle Company, owners of an extensive private land grant encompassing virtually all of the 12 mile diameter volcanic crater, the group has drilled 17 geothermal steam wells. Of these 17 wells, six are producing wells and three are reinjection wells. Starting in June, 1978, three more wells will be drilled in the Redondo Creek field. The wells range in depth from 6,000 to 9,000 feet and cost up to $1 million each to complete.

The firm estimates they have encountered 2.5 million acre feet of high temperature (500° - 600°F) hot water and steam that could support a 400 MW generating plant for a 30 to 35 year period. They propose to develop with others a system with additional wells that would utilize the steam portion, about 35 percent of the resource, to drive generators to produce electricity.

## 30.4 Serious Development Problems

The narrow stripes of federal leased land on the periphery of the Baca Location NO. 1 really does not offer much development opportunity and developers don't have any flexibility in exploration.

Union Oil and PNM will have to prepare and submit an Environment Impact Statement to DOE. The whole review process by DOE on the EIS will then take 13 months. Although a DOE grant is given for the demonstration power plant program to Union Oil, no money will be allocated until December 1979, when the EIS is completely reviewed with satisfaction.

Negotiation for transmission line right-of-way through National Forest land is being handled by PNM, who has had prior dealings with the Forest Service, and a good reputation for doing a careful job. The transmission line will handle at least 250 MW and possibly up to 400 MW.

The plant will use the Stretford process, in which hydrogen sulfide is oxidized to sulfur and water to capture 90% of the hydrogen sulfide in the steam and water. The escaping 1% will, hopefully, not exceed the one hour average of three parts per billion standard. The hydrogen sulfide content of the steam - water is considerably less than at the Geysers, in California, where the allowed emission is 30 ppb. The need for a permit to operate is over two years away, so there is time to evaluate and solve the problem before the plant goes on line.

## 30.5 Development Scenario

Development is in the advanced stage; the schedule presented here starts with the present stage, in which additional wells are being drilled and financial arrangements are being made to fund construction of the generating plant.

Further plant designing is taking place, particularly pipeline transportation. Construction of plant should begin in 1980.

# Table 16

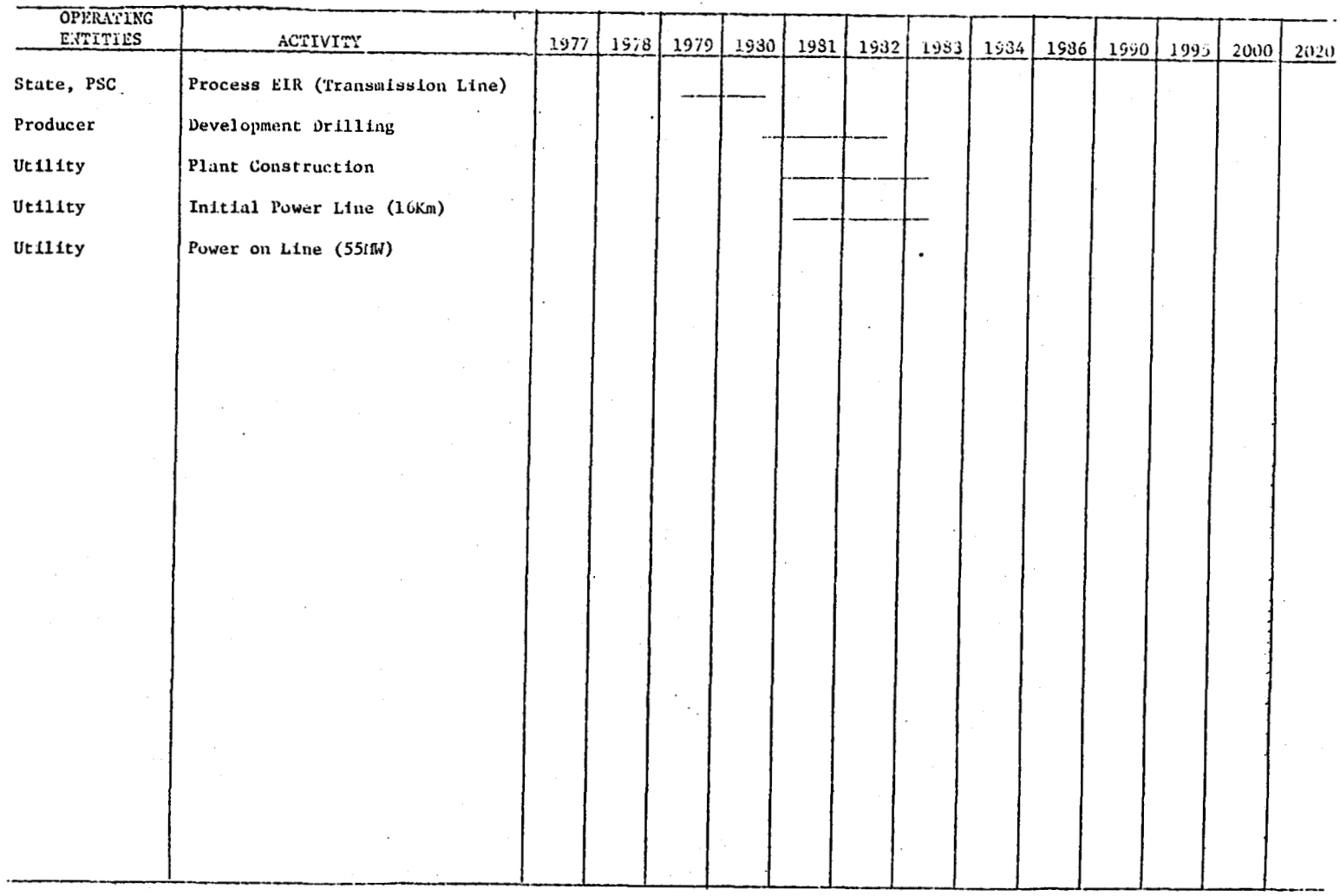
POSTULATED SITE DEVELOPMENT SCHEDULE
VALLES CALDERA

WBS 7001

| OPERATING ENTITIES | ACTIVITY | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1986 | 1990 | 1995 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State, Owner County | Issue Permits -- Exploration, Drilling of T.G. holes | | | | | | | | | | | | | |
| Owner, State | Lease Land | | | | | | | | | | | | | |
| Developer | Preliminary Geophsical Exploration | | COMPLETED | | | | | | | | | | | |
| Developer | Exploratory Drilling and Reservoir Evaluation | | | | | | | | | | | | | |
| Developer | Develop Utility Interest | | | | | | | | | | | | | |
| Developer & Utility | Feasibility Study | | | | | | | | | | | | | |
| Developer & Utility | Financial Negotiations | — | — | | | | | | | | | | | |
| Developer & Utility | Prepare and submit proposal to DOE | — | | | | | | | | | | | | |
| Developer & Utility | Site Selection | | — | | | | | | | | | | | |
| Developer & Utility | Design | | — | — | | | | | | | | | | |
| Developer & Utility | Commitment to Development | | • | | | | | | | | | | | |
| Developer & Utility | Prepare Environmental Data Statement | | — | — | | | | | | | | | | |
| State, PSC | Certify Plant & Site, Issue Permits | | | — | — | | | | | | | | | |
| State | Process EIR (Drilling) | | | — | — | | | | | | | | | |
| State, PSC | Process EIR (Plant) | | | — | — | | | | | | | | | |

POSTULATED SITE DEVELOPMENT SCHEDULE
VALLES CALDERA

WBS 7001




Possible Subsequent Additions (MWe) and On Line Date: 100-1986, 100-1988, 100-1990, 100-1991, 100-1992, 100-1993, 100-1994, 100-1995, 100-1996, 100-1997, 100-1998, 100-1999

## Table 17

Composite Scenarios for Direct Utilization of Geothermal Resources in New Mexico

| Site and Activity | Total MWth | 78 | 80 | 82 | 84 | 86 | 88 | 90 | 92 | 94 | 96 | 98 | 2000 | 02 | 04 | 06 | 08 | 10 | 12 | 14 | 16 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Socorro Spg. (Campus heating | 30 | | | | | 10 | 20 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 20 |
| Kilbourne Hole (Las Alturas & Anthony; Space Heating, Crop Drying, etc.,) | 50 | | | | | 20 | 40 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 30 |
| Radium Spg. (Green houses, Crop dehydration) | 50 | | | | | 20 | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 30 |
| Jemez Spg. (Space heating, Agriculture) | 60 | 3 | 3 | 3 | 23 | 43 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 57 | 57 | 37 | 17 |
| T or C (Space heating, recreation) | 30 | 2 | 2 | 2 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 28 | 28 | 28 | |
| San Ysidro (Space heating) | 20 | | | | | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Animas (Space heating, green houses) | 40 | 2 | 2 | 22 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 38 | 38 | 18 | |
| Albuquerque | 50 | | | | | 20 | 40 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Cumulative Total | | 7 | 7 | 27 | 93 | 193 | 290 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 330 | 323 | 323 | 313 | 237 |

## Table 18

Composite Scenarios for Geothermal Power Generation in New Mexico

| Site | Total MWe | 80 | 82 | 84 | 86 | 88 | 90 | 92 | 94 | 96 | 98 | 2000 | 02 | 04 | 06 | 08 | 10 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Animas | 100 | | | | 20 | 20 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Kilbourne | 50 | | | | 10 | 25 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Lower San Francisco | 20 | | | | | | 15 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Radium Spring | 30 | | | | | 5 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Valles Caldera | 2000 | | 50 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 |
| Cumulative Total | | | 50 | 100 | 230 | 350 | 595 | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 |

## STATE OF NEW MEXICO ENERGY SUMMARY

The State of New Mexico exports much more energy than it uses. Large quantities of uranium, oil, natural gas, and some coal are exported annually. Natural gas is currently the primary fuel used by the industrial, residential, and commercial sectors of the state.

New Mexico's industrial sector is relatively small however, it is the largest energy-using sector in the state, accounting for 35% of the total state energy consumption. Approximately 30% of the state's industrial energy consumption goes to the food and kindred-products industry, the wood and lumber industry, and the stone, clay, and glass industry.

The residential and commercial sectors combined are responsible for approximately 25% of the state's energy consumption. Due to the wide range of climates in New Mexico, space conditioning requires air conditioning as well as space heating, space conditioning accounts for approximately 50% of the residential commercial energy requirements.

The Energy Information Administration's recently published annual report estimates that the southwest United States will experience an approximate 2.7% increase per year in energy consumption. This normalized percentage increase will approximately double the New Mexico 1975 energy use by the year 2000.

FIGURE 17

NEW MEXICO ENERGY CONSUMPTION

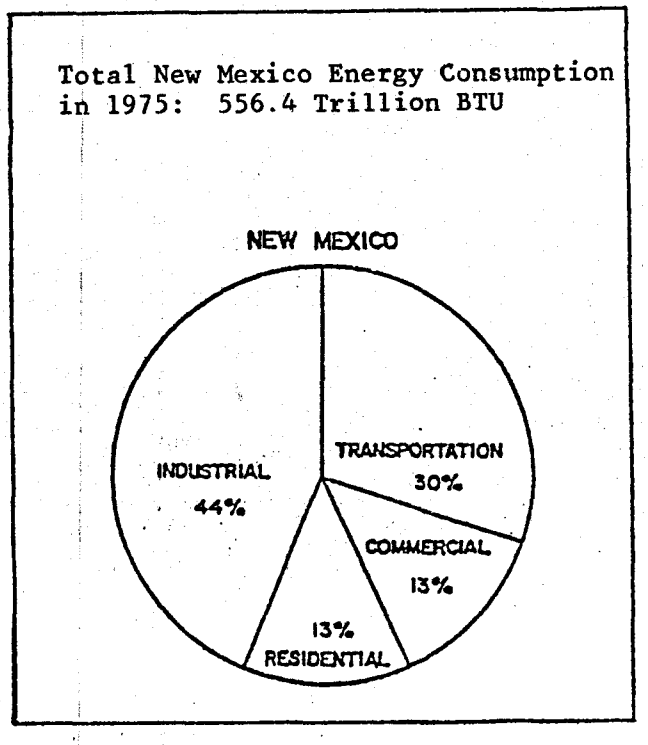


Figure 18. Total New Mexico Energy Production

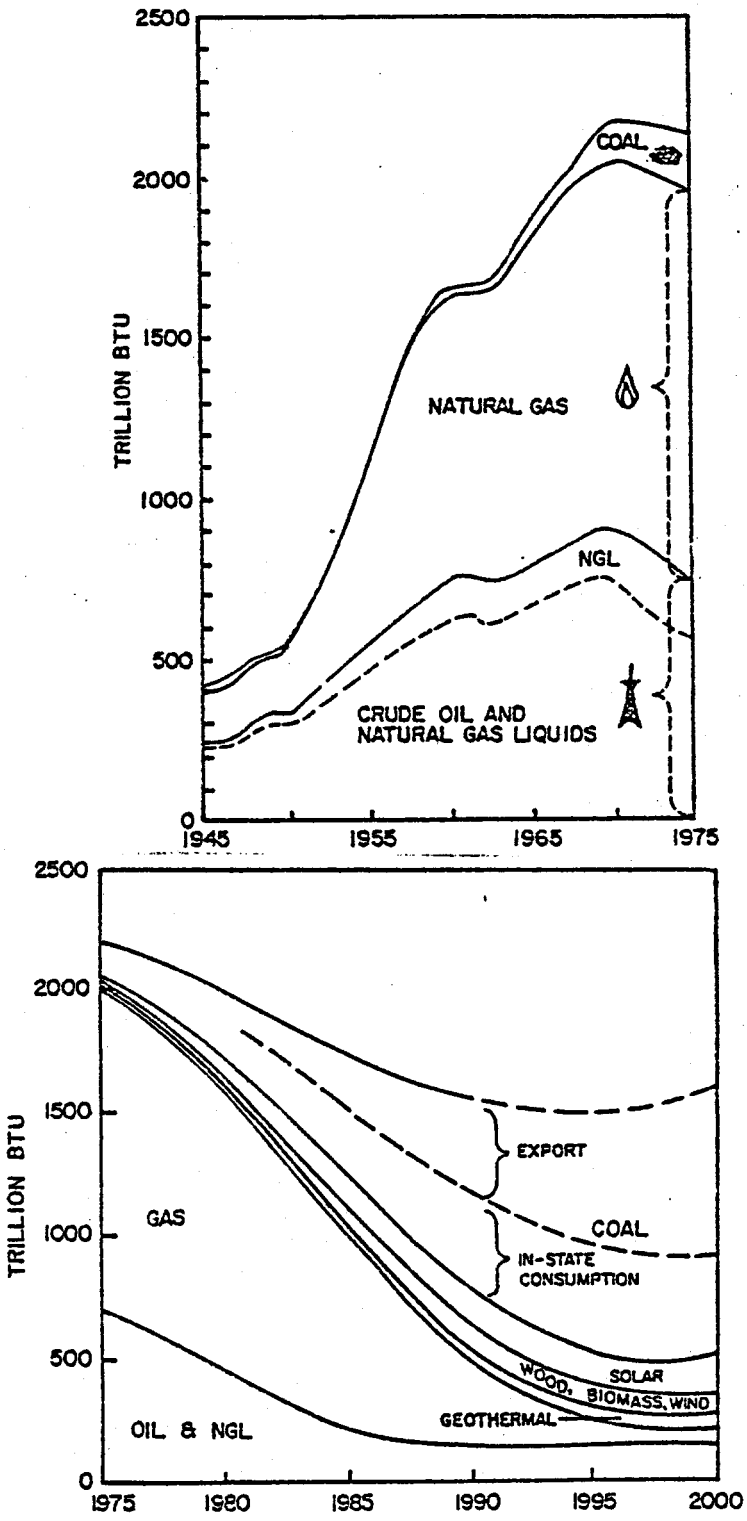



Figure 19. Estimated Future New Mexico Energy Production

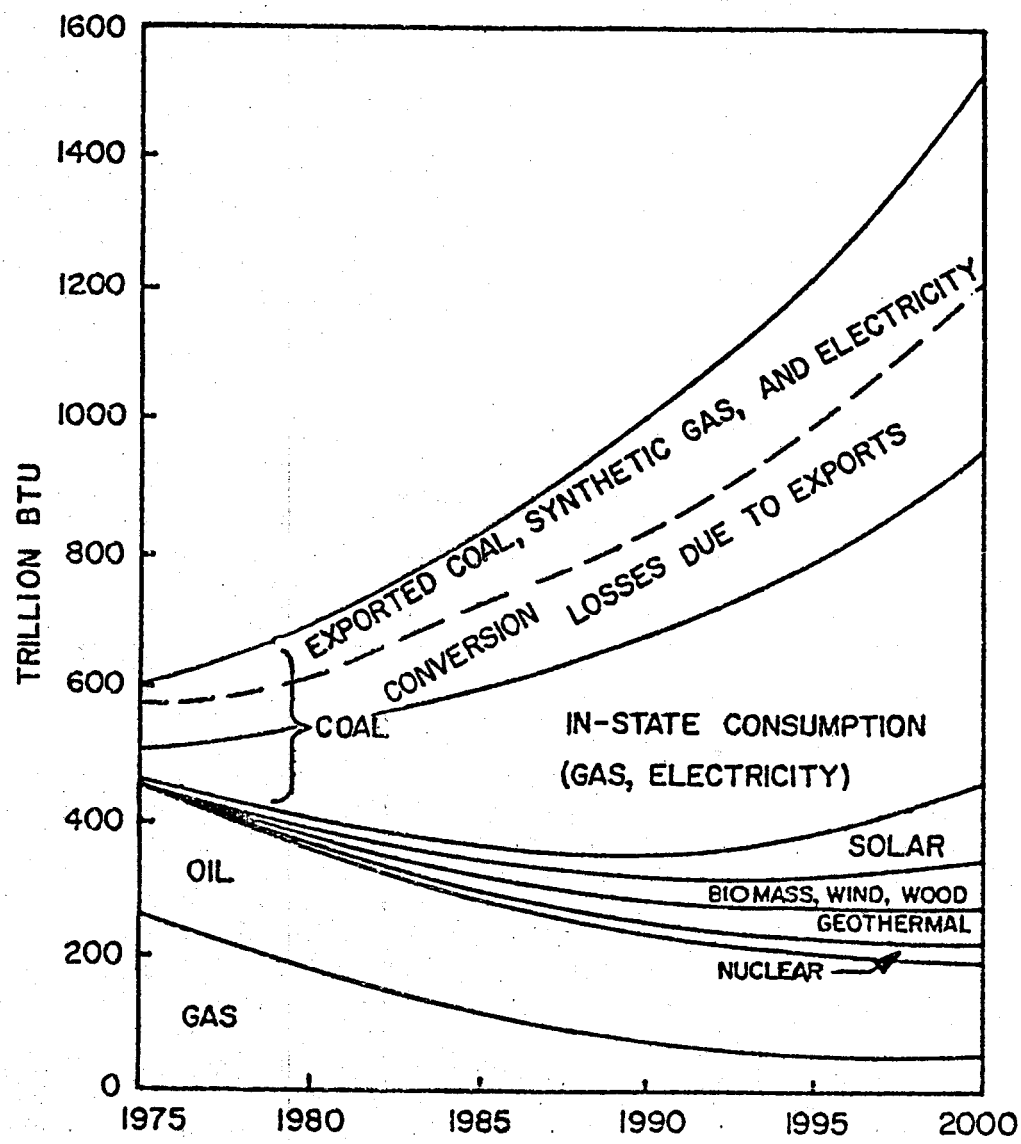



FIGURE 20

Energy consumption in New Mexico by supply source to the year 2000 (including coal export)

Source: Lumsdaine & Lumsdaine,

NMEI 14, 1978

## CONSTRAINTS TO GEOTHERMAL DEVELOPMENT

Several conditions have constrained geothermal development in New Mexico. Among the most prominent are federal regulations and procedures for leasing and permit approval and the lack of financial incentives. Other conditions may limit development in the future. Among these are state water policy and laws. Probably the most restrictive constraint, though, is the lack of a system for delivery of geothermal energy for direct use. The following describes these factors working against geothermal development interests in New Mexico.

### ECONOMICS

Basically, geothermal development is a costly and "high risk" effort. The actual development of this resource is still in its initial stages in many respects. Locating geothermal resources is not an easy task and, when the reservoirs are located, the development of them involves a high investment risk.

The current tax structure provides no incentives for the encouragement of geothermal exploration.

Financing of geothermal projects can be a serious problem, even though a number of uses are economically feasible, barring retrofitting. Small communities or small business often lack funds to cover substantial front-end expenditures. Lenders may be reluctant to risk funds on innovative or untested projects. In some western states, bond issues are frequently defeated because of the reluctance or inability of taxpayers to become more heavily obligated. In fact, many communities in New Mexico with limited staffs may be severely limited in their ability even to prepare applications for federal grants.

Leases and permits - One severe constraint is the inability of developers to obtain the necessary leases. The checker-board pattern of leases puts many companies in poor land positions for exploration. Many of the companies have explained that unleased land adjacent to leases inhibits exploration. Such open land might be leased by competitors taking advantage of tests on the adjacent leased and explored land. Many resource areas look promising but further exploration is being held up until the adjacent land is leased.

Even if all other conditions are favorable, without leases to protect the company's investment, no development can proceed. In New Mexico, leases on national forest lands are needed in the Santa Fe and Gila districts. Applications for leases on national forest lands have been pending since 1974. In light of the failure of the Forest Service to aid in the issuance of leases, it seems probable that their goals conflict with the goal of acceleration of geothermal development. The problem may well be one of conflicting legislative mandates, which can only be resolved legislatively.

Obtaining permits for geothermal operations on federal lands is sometimes a long and tedious process. Such delays can cause investment funds to be

diverted to other investments. Investors will not commit monies unless they can expect a return from their investments as soon as possible. Furthermore, such delays can simply frustrate potential developers such that they abandon the effort.

No state lands have been put up for bid since 1975. Many state leases are expiring and they cannot be renewed if they are not producing. Legislature is needed to change the lease terms from five to ten year term before the State Land Office can announce further sales.

Technology - There are no apparent major constraints to geothermal development arising from technology deficiencies. What could be a problem, however, is that sufficient amounts of the necessary equipment and services might not be available. This includes drill rigs, pipe and other hardware , plus the skilled workers to build and operate the equipment. Furthermore, an increased demand could in the future increase geothermal development costs such that geothermal energy is still not competitive.

Environmental Reports - The most commonly voiced complaints by developers is the repetitive requirements for environmental statements and plans of operation from companies for each step of exploration drilling.

System Development - Although industry is undertaking high-temperature geothermal development, currently no formalized system for low-temperature geothermal development exists in New Mexico. Technicians in numerous fields are evaluating resources, potential uses and constraints, and potential users are exploring geothermal applications in various industrial and agricultural processess. Communities are planning establishment of district heating systems. But for a commercial geothermal energy industry to develop, in this as in any other commercial venture, able and determined enterpreneurs must see and then seize the opportunity to make a profit. Few people are aware of the potential of the resource, know how to use it, and have the necessary funds to develop it.

Water Resources and Water Rights - Concern exists throughout the entire western region of the U.S. over the affect that the withdrawal of geothermal waters will have on existing water tables used for agricultural, municipal and other purposes. Temporary draw-down of local water tables by temperature gradient holes has been reported, for example in Utah. The geothermal industry maintains that its deep wells for electrical power production extend far below the depths of municipal and agricultural wells and into entirely different aquifers, but the potential for legal disputes over water rights continues to exist wherever any part of a geothermal installation touches surface waters or aquifers which supply surface waters.

The availability of water will be a major consideration in New Mexico as in other western states. Most projects will need to avoid excessive consumptive use of water. Heat exchangers can be of help where practicable, as can reinjection of the fluid.

Some of these conditions are now limiting geothermal development. Others are possibilities that may or may not occur in the future. Some conditions are controlled by the federal government, some by the energy industry, some by potential users and potential enterpreneurs, others by the physical attributes of the sites. The U.S. Department of Energy, Geothermal Resources Division, is making a concentrated effort to find ways to relieve

constraints to geothermal development. In New Mexico appropriate legislation and policy will continue to be enacted that would encourage the use of geothermal resources.

## LEGAL AND INSTITUTIONAL FACTORS AFFECTING GEOTHERMAL DEVELOPMENT

The New Mexico state team achieved a great deal of success in identifying problems, in the legal and institutional areas of geothermal development and formulating remedies. Institutional barriers were identified in the form of federal, state, and local government laws and regulations, such as environmental controls, leasing, permitting, tax laws, and land use policies. This was done through the examination of statutory regulations and court cases. The oil companies and developers were consulted concerning their experience in obtaining geothermal leases and meeting regulatory requirements. Since August, the Energy & Minerals Department in Washington, D.C., has been in touch with the state's congressional senators in an effort to include favorable treatment of geothermal energy in the National Energy Act.

### 1. State Legislation

The New Mexico Legislature is expressing interest in geothermal energy with some incentives for its development. The 1977 legislature, by a joint memorial, requested the Energy Resources Board and other state agencies to study the feasibility of heating state office buildings with geothermal energy.

The resulting state legislative report (Hatton, 1977) concluded that there is little evidence presently available to indicate any potential geothermal resource beneath Santa Fe. However, it stated that "conversion to geothermal space-heating for numerous state-controlled buildings in /areas of potential/ could, if feasible, save the state large sums of money."

In the special session in 1978, the legislature appropriated $200,000 to establish Geothermal Space Heating Demonstration Projects. This requires 100% matching funds from federal, local or private sources (see Table 13).

### 2. Legal Provisions

The New Mexico Legislature, in 1967, enacted the Geothermal Resources Act requiring all state lands to be leased through competitive bidding only. Lease terms are for an initial five years. As a result, there are many state leases expiring due to the short term and cannot be renewed. The act restricts the size of any lease to between 640 and 2,560 acres and prohibits any lessee from leasing over 25,000 acres in New Mexico.

The act provides for royalties of ten percent of the gross revenue, excluding transmission charges, received from the sale of steam and eight percent of the net revenue received from the operation of an energy plant and provides for an annual rental fee of one dollar per acre. However, the commissioner of public lands may suspend or reduce royalties and rentals if he finds it necessary to promote development. Other lease requirements and bonding provisions are contained in the act as are certain provisions relating to resource conservation and surface protection. In addition, the commissioner is given broad powers to impose other requirements and terms either by lease negotiation or by regulation.

In 1973, the legislature directed the Oil Conservation Commission to regulate the drilling, development and production of geothermal resources and to conserve and prevent waste of geothermal resources in the same manner as it regulated, conserved and prevented waste of natural gas. This general directive was followed, in 1975, by the enactment of the Geothermal Resources Conservation Act (Section 65-11-1 through 65-11-24, NMSA 1953). The act prohibits waste and gives the Oil Conservation Commission broad powers to prevent waste and protect correlative rights. Under the act the commission may: have access to records, require reports; regulate drilling and plugging of wells; limit, allocate, or distribute production; establish spacing units and prevent discrimination in the buying and selling of geothermal resources.

The 1975 legislature also enacted two additional acts relating to geothermal energy. The Energy Research and Development Act (Sections 65-12-1 through 65-12-8, NMSA 1953) created a fund, administered by the Energy Resources Board, for the purpose of financing research or development projects in the energy field. The specific purpose of the act is "to provide the means to seek solutions to fuel and energy problems through energy research and development for benefit to the citizens of New Mexico in the fields of wind, solar, geothermal, fossil, nuclear and all other research...."

The New Mexico Legislature has been quite concerned over the extraction and exploration of the state's natural resources and the resultant benefits to the state for its present and future citizens. Therefore, it has enacted such taxation measures as the resources excise tax, the severance tax, the oil and gas severance tax and the electrical energy tax. None of these taxes specifically apply to geothermal resources although there may be some future debate on whether or not geothermal resources may be considered a "mineral" within the meanings of those acts. There is currently only tax specifically levied on geothermal development, the oil and gas conservation tax. The tax is levied at a rate of nineteen one-hundredths of one percent on the sale value of geothermal energy less transportation costs and royalties. The proceeds of the tax are used to insure proper abandonment of oil and gas wells and to help pay the expenses of the Energy and Minerals Department

New Mexico's income tax is based upon federal taxable income. Therefore, any tax incentives passed by Congress, such as the deduction for intangible drilling costs and the depletion allowance which are included in the various versions of the National Energy Act now before Congress, would be passed on to New Mexico taxpayers.

## Court Cases and Litigation

There have been no court cases concerning geothermal development in New Mexico. However, there are many potential problem areas which will ultimately have to be resolved, either by legislation or litigation. One of these areas concerns whether geothermal resources are "minerals" in cases where the mineral estate has been severed from the surface estate by a grant or reservation of mineral rights.

TABLE 19

## SUMMARY OF STATE LAWS OF 1978 LEGISLATIVE SESSION AFFECTING GEOTHERMAL LEASING AND DEVELOPMENT

### Bills That Passed

#### House Bill 199: Research and Development Appropriation

Authorized $2,500,000 to continue energy research and development and the New Mexico Energy Institute.

#### Senate Joint Memorial 2

Requested the President to assure that New Mexico is selected as the site for a geothermal demonstration plant. (PNM and Union Oil have submitted a proposal to DOE for $100,000,000 to design and build the plant at Valles Caldera.)

#### House Bill 2: General Appropriation, Item 14 - Geothermal Space Heating

Appropriates $200,000 to the Energy and Minerals Department, Resources and Development Program, for establishing geothermal space heating demonstration projects. 100% matching funds required.

### Bills That Did Not Pass

#### Senate Bill 199: Geothermal Leases

Would have allowed up to ten years to go into production, instead of the five years now stated by law.

#### House Bill 193: Geothermal Space Heating Demonstration Projects

Would have appropriated $2,500,000 to the Energy Resources Development Fund for establishing geothermal space heating demonstration projects. 100% matching funds required.

## SUMMARY AND CONCLUSIONS

This 14 month study has attempted to estimate the potential for geothermal resource development in New Mexico. It has also attempted to identify those conditions that seem to impede that development. As a third objective, it has attempted to identify those actions that seem necessary to advance the development of geothermal resources.

The results show that geothermal resources in New Mexico do have significant potential particularly in the Rio Grande Rift area. Geothermal energy in the amount of $18.2 \times 10^{18}$ calories was estimated to be in the 49 hydrothermal (hot water) systems identified in New Mexico.

However, geothermal energy use is limited by the distance it can be transported. For that reason, industry has been interest primarily in high-temperature resource for power generation.

New Mexico's largest resource area, the Valles Caldera, is currently in the development phase. For other areas, some leases have been issued, and some preliminary exploration has occurred. Planning and preliminary studies that are both completed and underway may lead to their development in the near future. Seemingly, interest in and awareness of the resources is growing. If leases and permits are made available, along with some economic incentives, some or all of the six potential power-generation sites may be developed by private industry. Perhaps with the assistance of Federal programs initially, lower temperature resources, too, will be developed by private industry. While government can provide opportunities, the outcome depends upon the decisions of numerous individuals throughout the system.

Geothermal resources in New Mexico may turn out to be rather important, not necessarily in generating electricity for export, but to supply energy for use in the state, especially for direct application in agri- and horticulture, for industrial process heat, and for heating and refrigeration, and these areas should be further explored and developed. New Mexico State University is investigating the potential of the nearby Los Alturas geothermal wells for heating campus buildings.

Geothermal energy should preferably be used directly as heat, because conversion into electricity and back into heat is very inefficient. However, it may be possible to gain sweet water as a desirable biproduct through the electric generation process from a high-temperature water convection system and this aspect should also be investigated in detail.

Before extensive development can take place in the state, legal questions will have to be considered with regard to its extraction, comparable to mineral rights, water laws, depletion allowances, etc. Who owns the geothermal resources? How should wells be operated and taxed to minimize depletion? Exploration for geothermal resources is far from complete in New Mexico, and no attempt has yet been made to outline in detail the extent of geothermal resources (recoverable earth heat) in the state. This is necessary together with on-site testing to define New Mexico's geothermal reserves which are geothermal resources competitive with existing energy resources.

TABLE 20

SOME POTENTIAL USES FOR GEOTHERMAL RESOURCES

IN NEW MEXICO

POWER GENERATION

SPACE HEATING OF SCHOOLS, OFFICES, STORES, HOMES, WAREHOUSES, AND GREENHOUSES

WATER HEATING

SPACE COOLING

HIGHWAY DE-ICING

FRESH-WATER BY DISTILLATION

BIOMASS PROCESSING FOR FUEL, FERTILIZER

FEEDLOT WARMING

LIVESTOCK PEN WARMING FOR POULTRY, HOGS

WOOL WASHING AND DRYING

FISH HATCHERIES AND FISH FARMING

APPLE, PEACH, PEAR, PRUNE, APRICOT DEHYDRATION AND FREEZE-DRYING

POTATO, ONION, CARROTS, TOMATO, BELL PEPPER, CHILI DEHYDRATION

REFRIGERATION OF FOOD PRODUCTS SUCH AS FRUIT, LETTUCE, SPINACH

WOOD CHEMICALS

MANUFACTURE OF PLYWOOD, VENEER, PARTICLE BOARD, LUMBER CURING

PAPER AND PULP

DAIRY FARMING INCLUDING MILK CHILLING, PASTEURIZATION & CHEESE MFG.

MUSHROOM GROWING

FREEZE DRYING

DRYING AND CURING LIGHT AGGREGATE CEMENT SLABS

SOIL STERILIZATION

SOIL WARMING

SEED DRYING

POULTRY HATCHING

SWIM POOLS, BATHS

TROPICAL GARDENS

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Walt Kowak, Bureau of Land Management, Las Cruces

William Laughlin, Jim Maxwell, and Francis West, Los Alamos Scientific Laboratories

Tom McCant, Rancher and farmer, Animas

Chuck McGlothin, District Ranger, USFS, Jemez Springs

Dr. Richard T. Meyer, Western Energy Planners, Consultants to the Southwest Regional Geothermal O/R Project

Harry Olson, Amax Exploration, Denver, Colorado

Jim Querry, Bureau of Land Management, Santa Fe

Marshall Reiter and William Stone, New Mexico Bureau of Mines

Dr. Allen Sanford, New Mexico Institute of Mining & Technology

Dr. R. San Martin, Director, New Mexico Energy Institute

Dr. Chandler Swanberg, New Mexico State University

Carl Ulvog, New Mexico Oil Conservation Division, EMD

# A P P E N D I X  1

## STATE OF NEW MEXICO

## GEOTHERMAL ENERGY PLAN

# GEOTHERMAL ENERGY

## The Current Situation

Geothermal energy, the natural heat in the earth's crust, has a large potential for direct thermal use and for electrical generation in New Mexico. Recent studies rank this state in the top five in almost every geothermal resource category.

New Mexico's hydrothermal (liquid dominated) sites, located throughout the central and southwestern portions of the state, are presently of the greatest economic interest. Some of these sites contain water hot enough to be used for electrical generation; many contain water too cool for that purpose but warm enough to heat buildings.

In addition, to more than 100 hot springs and numerous volcanoes that, in geological reckoning, can be classified as recently active, New Mexico's borders enclose part of a major underground heat anomaly associated with the Rio Grande Rift. Most of the state's population is located along this rift -- a coincidence that may someday be advantageous to large-scale geothermal development.

Many projects that will partially utilize New Mexico's enormous geothermal potential are now under way. Interest has been shown by private industry, the State, municipalities and the federal government.

The most important project, at least from the short-range economic standpoint, is presently a 50 MW generating facility to be constructed by the Public Service Company of New Mexico and the Union Oil Company in the Valles Caldera west of Los Alamos.

The U.S. Department of Energy has tentatively approved funding for this facility and the plant is scheduled to begin operation in 1982 if final approval is given. It will be one of the nation's major geothermal installations.

An important experiment utilizing hot, dry rock is now being undertaken by the Los Alamos Scientific Laboratory near Fenton Lake. Here cool water is pumped deep into the ground, heated by fractured rocks and recovered as steam. From this experiment, the only one of its kind in the U.S., a great deal has been learned about the hot dry rock process. The installation has a theoretical capacity of 10 MW (electrical).

Sunoco Development Company, Amax Exploration, Chevron Oil, Sandia Laboratories and the State of New Mexico are drilling or will soon drill into hydrothermal systems in New Mexico, and numerous other entities hold geothermal leases that are expected to lead to hydrothermal drilling programs.

Working against geothermal development interests in New Mexico are the following factors:

Economics - Basically, geothermal development is costly and involves a high degree of risk. Utilization of this resource is still in its initial stages in many respects. It is not always easy to find geothermal reservoirs, and when a reservoir has been found, individual wells may still fail to yield water of sufficiently high temperature or in sufficient quantity. Because of these risks and the high cost of development, only a few buildings in New Mexico presently use geothermal energy for heating and cooling.

Water Resources and Water Rights - Concern exists throughout the entire western region of the U.S. over the affect that the withdrawal of geothermal waters will have on existing water tables used for agricultural, municipal and other purposes. Temporary draw-down of local water tables by temperature gradient holes has been reported. The geothermal industry maintains that its deep wells for electrical power production extend far below the depths of municipal and agricultural wells and into entirely different aquifers, but the potential for legal disputes over water rights continues to exist wherever any part of a geothermal installation touches surface waters or aquifers which supply surface waters.

Lease Acreage Limitation - The 25,000-acre state limitation on geothermal leasing and the associated time limit of five years on exploration leases pose another kind of problem. The time period from lease application to commercial energy production is 6 to 12 years, with a majority of those years required for the various regulatory and institutional processes (permits, EIS's, etc.). The acreage limitation often forces a developer to discontinue his lease before exploration or development can be completed, because often a developer cannot acquire new land without divesting himself of land he already has. The time-acreage limitation also tends to cause developers to drill hastily and in the wrong places.

## Policy Statement

The policy of the State of New Mexico shall be to encourage development and demonstration of technologies both for the production of electrical power and for direct thermal use from New Mexico geothermal resources, and to provide for continued expansion of the utilization of this viable energy resource in an environmentally acceptable manner.

## Implementation of State Policy

The following steps should be taken to implement State policy:

1. The State should continue to fund geothermal projects from the Energy Research and Development Fund. Emphasis should be given to projects that will result in drilling programs utilizing information obtained from previous projects.

2. The State should initiate a geothermal space heating demonstration project. In this regard, the 1978 New Mexico Legislature has appropriated $200,000 to the Energy and Minerals Department to be used as matching monies for a space heating demonstration project. Applications for the project are tentatively scheduled to be called for by October, 1978 and will be based on the results of a "low temperature geothermal assessment project" currently in progress.

The assessment project utilizes $15,000 in state energy research and development funds and some $150,000 in federal monies.

It appears that the principal candidates for demonstration project funds this year will be New Mexico State University, the New Mexico Institute of Mining and Technology, the University of New Mexico and the village of Jemez Springs.

3. The State should adopt the following fiscal policies to stimulate geothermal development:

* Extend the State geothermal lease duration from 5 years to 10.

* Expand the maximum geothermal leasing acreage allowance from 25,000 acres to 50,000

A bill addressing both of these points has been prepared for introduction in the 1979 legislative session.

4. Legal barriers to the development of geothermal resources should be resolved. Further study is needed on the question of whether or not geothermal resources are mineral resources and therefore subject to mineral rights.

5. A tax incentive should be initated for the retrofitting or outfitting of existing business and industry buildings, equipment and processes to utilize geothermal energy. This could be accomplished by adding a Section 72-15A-11.6 of the Income Tax Act to provide an income tax credit of 25 percent of the installed cost of a geothermal energy system, not to exceed $2,500. A bill to this effect has been prepared for introduction in the 1979 legislative session.

6. In order to relieve the demand for petroleum products, the State should encourage and expand development of geothermal space heat application wherever feasible in New Mexico.

7. The State should disseminate further information about geothermal energy utilization to the people of New Mexico through the Energy Extension Service and continue to expand planning assistance for geothermal projects, especially in the residential, agricultural and small business areas.

8. The State should, as is done in the case of solar energy, demonstrate its confidence in geothermal application. This could be done by installing geothermal space heating systems in new or existing State buildings where technically and economically feasible.

9. The State should continue to support efforts on the federal level to authorize a 22 percent depletion allowance for geothermal drilling operations.

# A P P E N D I X  2

## STATE OF NEW MEXICO

## GEOTHERMAL RESOURCE AND DEVELOPMENT PROJECTS

GEOTHERMAL PROJECTS CONDUCTED UNDER THE NEW MEXICO ENERGY RESEARCH AND DEVELOPMENT ACT (1974-1979)

| Project ID | Project Title | Funding | Status |
|---|---|---|---|
| BEF-5 Reiter NMIMT | As Investigation of the Thermal Regime of the Rio Grande Rift and Neighboring Provinces by Employing Very Deep Heat Flow Measurements and Estimates of Crustal Radioactive Heat Generation | $53,200 | Complete |
| BEF-6 Sanford NMIMT | Seismic Investigation of a Magma Layer in the Crust Beneath the Rio Grande Rift near Socorro, New Mexico (and Its Relation to the Geothermal Energy Potential of the Region) | $23,444 | Complete |
| BEF-22 Jiracek UNM | Geothermal Potential of Rio Grande Rift, New Mexico | $74,870 | Complete |
| BEF-67 Swanberg NMSU | Geothermal Investigations in Southwestern New Mexico | $58,876 | Complete |
| BEF-131 Reiter NMIMT | Geothermal Gradient Measurements | $ 2,900 | Complete |
| BEF-166 Landis UNM | Oxygen Isotope Geochemistry and Geothermal Energy Potential in New Mexico | $18,600 | In Progress (Final Report Only) |
| BEF-189 Swanberg NMSU | Geothermal Equipment | $ 1,600 | Complete |
| ERB 75-107 Hsu UNM | Engineering Methods for Predicting Productivity and Longetivity of Hot-Dry-Rock Geothermal Energy Reservoir in the Presence of Thermal Cracks | $48,682 | Complete |
| ERB 75-117 Callender | Evaluation of Geothermal Potential of the Basin and Range Province of New Mexico | $105,928 | Complete |
| ERB 75-300 Sanford NMIMT | Seismic Exploration for Shallow Bodies in the Vicinity of Socorro, N.M. | $22,020 | Complete (Final Draft revision) |

GEOTHERMAL PROJECTS (continued)

| Project ID | Project Title | Funding | Status |
|---|---|---|---|
| ERB 76-200 Reiter NMIMT | Deep Terrestrial Heat Flow, Measurements in New Mexico and Neighboring Geologic Areas | $20,000 | Complete (final draft revision) |
| ERB 76-201 Chapin NMIMT | Geological Investigation of Socorro Geothermal Area | $28,650 | Complete (final draft revision) |
| ERB 76-205 Gunaji NMSU | Geothermal Application Feasibility Study for the NMSU Campus | $34,249 | Complete |
| ERB 76-210 Stone NMIMT | The New Mexico Geothermal Potential | $ 8,000 | Complete |
| ERB 76-213 Miller NMIMT | Geothermal Application Feasibility Study for the NMIMT Campus | $29,963 | Complete |
| ERB 76-260 LaFrance NMSU | Feasibility Study of Geothermal Energy for Heating Greenhouses | $10,819 | Complete (final draft revision) |
| ERB 76-261 Chaturvedi and Keys NMSU | Use of Geothermal Energy Desalination in New Mexico - A Feasibility Study | $31,149 | In Progress (extension requested) |
| ERB 76-262 Zwerneman NMSU | Regional Operations Research for Development of Geothermal Energy Resources in the Southwestern United States | $100,000 | In Progress |
| ERB 76-263 Sanford and Schule NMIMT | Seismic Exploration for Shallow Magma Bodies in the Vicinity of Socorro, New Mexico | $37,850 | In Progress |
| ERB 76-264 Callender UNM | Evaluation of Geothermal Potential of the Basin and Range Province of New Mexico | $103,235 | Complete (final draft revision) |
| ERB 77-2113 Hsu UNM | An Enhanced Heat Extraction From Dry Rock Geothermal Reservoirs Due to Interacting Secondary Thermal Cracks | $10,000 | In Progress |

GEOTHERMAL PROJECTS (continued)

| Project ID | Project Title | Funding | Status |
|---|---|---|---|
| ERB 77-2203 Morgan NMSU | Active and Passive Seismic Studies of Geothermal Resources in New Mexico and Investigations of Earthquake Hazards to Geothermal Development | $50,000 | In Progress |
| ERB 77-2211 Energy Institute NMSU | Department of Energy and New Mexico Cooperative Program - Low Temperature Geothermal Reservoir Assessment | $15,000 | In Progress |
| ERB 77-2218 Chaturvedi NMSU | Los Alturas Geothermal Reservoir Confirmation Study | $20,000 | In Progress |
| ERB 77-2312 Sanford NMIMT | Seismic Exploration for Shallow Magma Bodies in the Vicinity of Socorro, New Mexico | $36,510 | In Progress |
| ERB 77-2314 Hyakorn and Gelhar NMIMT | Development and Application of a Computer Model for Simulating a Geothermal System in New Mexico (Phase One) | $31,600 | In Progress |
| EMD 78-2120 Landis UNM | Computer Based Chemical and Stable Isotope Modeling of Geothermal Systems in New Mexico | $39,150 | In Progress |
| EMD 78-2122 Kaufman and Houghton UNM | Engineering and Economic Feasibility Study of Hot Water Geothermal Energy in the Albuquerque Area | $57,681 | In Progress |
| EMD 78-2123 Elston UNM | Assessment of the Geothermal Potential of Southwestern New Mexico | $28,820 | In Progress (awaiting federal funding) |
| EMD 78-2135 Jiracek UNM | Evaluation of the Geothermal Resource in the Area of Albuquerque, New Mexico | $76,874 | In Progress (awaiting federal funding) |
| EMD 78-2219 Energy Institute NMSU | Feasibility Study for Establishing a Centralized Geothermal Data Base for New Mexico | $ 6,000 | In Progress |

GEOTHERMAL PROJECTS (continued)

| Project ID | Project Title | Funding | Status |
|---|---|---|---|
| EMD 78-2232<br>Young<br>NMSU | Electrical Exploration for Geothermal Resources near San Diego Mountain, New Mexico | $25,420 | In Progress |
| EMD 78-2234<br>Lansford<br>NMSU | Utilization of Geothermal Energy for Agribusiness Development in Southwestern New Mexico (Part One) | $76,214 | In Progress |
| EMD 78-2236<br>Marlin<br>NMSU | Southwest Geothermal Regional Operations Research Study | $100,000 | In Progress |
| EMD 78-2321<br>Reiter<br>NMIMT | Deep Subsurface Temperature Studies in the Basins of New Mexico and Neighboring Geologic Areas | $35,000 | In Progress |
| EMD 78-2333<br>Miller and LeFebre<br>NMIMT | Heating the New Mexico Tech Campus with Geothermal Energy (Part Two) | $13,944 | In Progress |

## GEOTHERMAL RESEARCH AND DEVELOPMENT PROGRAMS

### STATE PROJECTS

| Calendar Year | Number of Projects | Total Value of Projects |
|---|---|---|
| 1974 | 3 | $135,520 |
| 1975 | 6 | $252,580 |
| 1976 | 5 | $108,633 |
| 1977 | 7 | $367,302 |
| 1978* | 15 | $572,713 |

*including Fiscal Year 1979 Awards

# APPENDIX 3

## Regional Federal-Sponsored Activities Attended by the New Mexico State Team

REGIONAL PLANNING WORKSHOP APRIL 26, 1978

The Southwest Regional Geothermal Development Operations Research Project, due to a organizational change in DOE/DGE, has recently come under the Rocky Mountain/Basin and Range Region.

The New Mexico State OR Team was represented at the planning workshop in Salt Lake City, on April 26, conducted by personnel from DGE Headquarters, DOE Idaho Opertions (ID), DGE Nevada Operations, U.S. Geological Survey, EG & G (the prime contractor to ID), and the Earth Science Laboratory of the University of Utah Research Institute.

Detailed short-and long-term planning activities included all aspects of stimulation of geothermal energy development from resource definition through utilization, encompassing presently existing programs as well as new programs.

Presentations by State Teams addressed the following topics:

(1) Location and nature of known geothermal sites with emphasis on the best sites in terms of development of electrical generating capacity or direct heat uses.

(2) Potential for further resource discovery.

(3) OR data generated to date and its applications.

(4) Recommendations for future DGE programs and initiatives.

REGIONAL PLANNING WORKSHOP JUNE 28, 1978

A second regional planning workshop was held in Salt Lake City on June 28 to review and comment on the DOE/DGE Draft Regional Hydrothermal Development Plan for the Rocky Mountain/Basin and Range Region. Representatives of industry also participated.

GEOTHERMAL STREAMLINING TASK FORCE WORKSHOPS

June 13, 1978 - Albuquerque

June 28 and 29, 1978 - Salt Lake City

The Interagency Geothermal Streamlining Task Force held a series of regional meetings that were held in 4 southwestern cities including Albuquerque.

The purpose was to present and discuss proposals from the Task Force aimed at streamlining the processes for issuing geothermal leases and related permits on Federal lands, as well as to encourage the submission of any new proposals from the public.

The Salt Lake City meeting on June 28-29 included workshop sessions and followed by one day a major DOE regional energy meeting that was attended by energy producers, utilities and governmental organizations from the Rocky Mountain Basin and Range Area including the New Mexico State Team.

The Task Force was formed to assist the Interagency Geothermal Coordinating Council (IGCC) carry out its mandate "...for developing recommendations for changes and improvements in...(geothermal)... related laws, policies and procedures..." Specifically, the Task Force is responding to the President's commitment to Congress that "The Depts of Interior and Agriculture will streamline leasing and environmental review procedures to remove unnecessary barriers to the development of geothermal resources."

The commitment was prompted by the fact that although the Geothermal Steam Act was passed nearly seven and one-half years ago, there is still no commercial production of this resource on Federal lands.

It is widely known that the cumbersome Federal leasing and permitting program constitutes a major deterrent to timely development. As long as the inhibiting influence of the regulatory program clouds the rate of development on Federal lands, the effects of other impediments cannot be fully and accurately assessed.

The Geothermal Streamlining Task Force has undertaken a study which includes (1) a comprehensive analysis of the elements of the present program designed to identify the sources of delay and quantify delays which are actually occurring; and (2) to determine the potential effects upon program performance of a series of options for program modification. The effectiveness of alternative options will be assessed in terms of their relative ability to support the Department of Energy's projected geothermal power-on-line schedule while adequately protecting the public interest and the environment.

The Albuquerque meeting was chaired by Task Force chairman, W.B. Short of the BLM, with the principal presentation by Bert Jones of DOE. Though attendance was rather sparse, some very pertinent questions and suggestions were offered by Jerry Hall of AMAX. The Task Force was supported by representatives from the US Forest Service, Geological Survey and Bureau of Land Management in this area. The workshop brought forth reviews and comments on the series of options developed by the Task Force, for modifying the geothermal leasing and permitting program.

The Task Force recommendations, massaged and/or amended as a result of the public review meetings was presented to the IGCC at a July 22 meeting in Hawaii.